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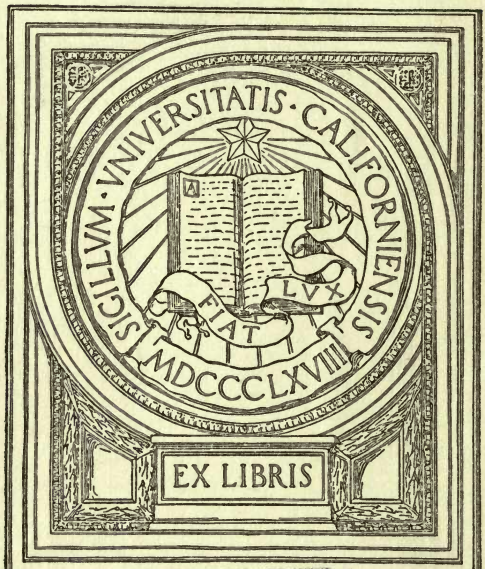
HANDBOOK OF INSTRUCTIONS FOR COLLECTORS

B. M.
(N.H.)



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HANDBOOK

OF

INSTRUCTIONS FOR COLLECTORS,

ISSUED BY
THE BRITISH MUSEUM (NATURAL HISTORY)

WITH 75 TEXT-FIGURES AND ONE PLATE.

FOURTH EDITION.

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PREFACE TO THE FIRST EDITION.

In past years the Museum collections have been greatly augmented and enriched by the donation of valuable series of specimens obtained by travellers and others whose vocations have necessitated their residence abroad in all parts of the world.

It often happens that military and naval officers, explorers, missionaries, and others have leisure time which they would be willing to devote to collecting natural history objects if they had a better knowledge of the manner in which such things should be collected and preserved.

In order to meet this requirement, it has been thought advisable to prepare a series of pamphlets treating upon the collecting and preservation of specimens in all branches of natural history. These can be obtained separately; but for the convenience and use of those who are willing to take up more than one branch of collecting, they are now united and issued in book form, thus forming an introductory manual of instructions on the subject generally.

Although primarily written for the use of voluntary collectors, this work will prove equally useful to those professionally engaged in collecting, as showing the approved manner in which the various objects referred to should be treated.

The various chapters have been written by different members of the staff of the Natural History Museum, with the hope that the distribution of this work will lead to the formation

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of important collections which will ultimately come to us for study and comparison, and possibly enrich the series preserved in the Museum.

E. RAY LANKESTER,
DIRECTOR.

June 1*st*, 1902.

The third edition of this Handbook was published in 1906. Material alterations have been made in the present edition, the most important of which are the addition of three new numbers, namely, 1A (Skeletons of Mammals, with special notes on Cetacea), 12 (Worms), and 13 (Alcohol and Alcoholometers). No. 9 (Soft-bodied and other Invertebrate Animals) has been greatly altered, and substantial changes have been made in 2 (Birds), 3 (Reptiles, Batrachians and Fishes) and 4–7 (Insects). For further information on many matters connected with collecting, preserving and labelling specimens, with particular reference to marine animals and plants and bottom deposits, "Science of the Sea," prepared by the Challenger Society and edited by Dr. G. H. Fowler (London, John Murray, 1912, price 6*s*.) may be specially recommended.

A certain amount of repetition in successive numbers has been found inevitable, in order to keep each part of the work as far as possible complete in itself.

The thanks of the Trustees are due to Sir James J. Dobbie, F.R.S., lately of the Government Laboratory, for revising No. 13, dealing with Alcohol and Alcoholometers; and it is believed that the account there given of a somewhat intricate subject may be regarded as authoritative.

SIDNEY F. HARMER,
DIRECTOR.

BRITISH MUSEUM (NATURAL HISTORY),
CROMWELL ROAD,
LONDON, S.W. 7.

March, 1921.

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Mammals, Part I.

SKINS, their Removal and Preparation.

I.—Large Mammals.

SPORTSMEN, as a rule, are by no means careful enough about the proper labelling of their specimens, which consequently lose much of their scientific value. Large Mammals, like small ones, should be carefully labelled, with all particulars of date, sex, locality, altitude, etc. Specimen-labels are shown on page 14. *The proper reference of each skull to its own particular skin is also of the greatest importance.*

For skinning large Mammals the instruments required are very few and inexpensive—a shoemaker's knife, a scalpel, a small saw, and a pair of pliers, with perhaps the addition of a pair of cutting-pincers, being all that are requisite. Any addition to this simple outfit only tends to encumber the traveller unnecessarily, everything really depending upon the skill with which the knife is wielded rather than upon the number and nature of the implements themselves.

The great principle the operator should bear in mind is to make as few incisions as possible in the skin, and to confine these, so far as practicable, to the middle line of the under surface of the body, and to the inner sides of the limbs. If this be attended to, the slits will be but little conspicuous if the specimens are mounted. In Mohammedan countries the natives have a practice of cutting the throats of animals from ear to ear immediately they fall, in order that they may be bled after the orthodox fashion. Such gashes have, of course, to be sewn up if the specimen is mounted, with the result that the region of the throat is disfigured by ugly seams. In his book, entitled "Seventeen Trips to Somaliland,"

Colonel Swayne has shown that by a little gentle persuasion the natives can be induced so to modify the *halal* (as the operation is called) that the damage to the specimen is reduced to a minimum; and probably a similar modification might be assented to by the Mohammedans of other countries.

In the case of a hornless animal, such as a Lion or Tiger, preparatory to commencing operations the carcass about to be skinned should be turned on its back, and the fore and hind limbs held outwards by assistants, as far as they can be easily stretched. The operator should then make a straight incision with the knife from the chin along the middle line of the under surface of the body to the tip of the tail. In making this and the other incisions great care should be taken to avoid cutting more than is necessary into the flesh, and, above all, not to lay open the cavity of the abdomen. The next procedure is to make cuts diverging from the main incision, in order to enable the limbs to be stripped. In the case of the fore legs the lateral cuts should be carried from the middle line through the armpits down the inner side of each limb, the knife being held pointing somewhat outwardly, in order that the seams made in sewing up the cuts should be as inconspicuous as possible if the specimen is mounted. In the hind limbs the incisions should be carried through the groin, and so downwards in the same manner as in the fore limbs.

In the case of horned animals (exclusive of Rhinoceroses, in which the horns are removed with the skin) it will be necessary, when the carcass is again turned, to make an incision from the crown of the head down the middle line of the neck to such a distance as will admit of the horns or antlers being passed through the slit thus made when the skin is removed from the head. In no case should the head-skin be severed from that of the body.

When all the above-mentioned cuts have been made, the skin of the chest will be left in the form of lappets. Commencing by the application of the knife to the point of one of these lappets, the skin should be gradually stripped from the body, tail, and limbs, special care and attention being requisite in order to avoid damaging the feet, of which the natural contour should be so far as possible preserved. In the case of the smaller specimens, whether Deer,

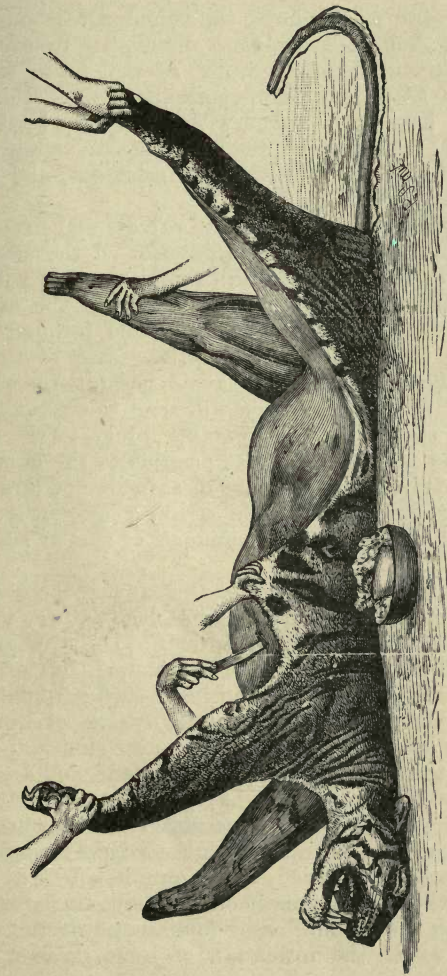

FIG. 1.—SKINNING A TIGER.
(From Rowland Ward's "Sportsman's Handbook.")

Antelopes, Carnivora, or Monkeys, the terminal toe-bones may be left in the skin; but their complete removal is desirable in the larger representatives of these groups, as well as in still bigger animals, such as Elephants, Hippopotamuses, and Rhinoceroses. Special measures have to be taken with these very large animals, but in the case of Carnivora and Monkeys the skin should be drawn over the bones of the toes by turning it inside-out, and the joints cut with the pliers where required.

The next process is to turn over the carcass and draw the skin forwards over the head, when the separation of the ears and the severance of the closely adherent skin round the eyes will demand somwehat delicate manipulation. The conchs of the ears should be severed close to the skull, in order to avoid forming apertures of too large size in the skin; and in the case of the eyelids particular care should be taken to avoid gashing the skin, since even the smallest slit in this region will tend to spread to a great extent, and thus cause almost irreparable injury to the specimen. The lips should be cut off as close as possible to the gums.

It may be added that in the case of animals not larger than a Fox, the skin of the tail may be stripped off entire, without slitting the under surface; but for animals of this or smaller size, see page 16.

Having now removed the skin from the carcass, the next process is to cut away completely all fragments of flesh and fat which may have been left adhering to its inner surface. The cartilages of the ears must also be dissected out with the scalpel, by turning back the skin over them; after which the inner surface should be well anointed with some preservative—powder, paste, or liquid. The scalpel must also be passed between the outer skin and the inner mucous lining of the lips, and the slit thus made well dressed with the same substance. The eyelids have likewise to be thoroughly dressed with preservative; and if necessary, on account of their thickness, they should be slit open with the scalpel from the inside.

The skin has now to be dried, which may be effected, if that of a large animal, either by pegging it out (without undue stretching) hair-downwards on the ground, or by folding and drying it in such a manner as to avoid the formation of large creases. Smaller

skins should always be folded and dried without creasing. Some preservative, such as alum, or one of the special preparations sold for the purpose by dealers, should now be well rubbed in, especially on the ears, mouth, feet, etc., and the whole specimen sprinkled with the same. The hairy side of the skin has next to be well anointed with turpentine, and the specimen will be ready for packing. When animals are shot during the rainy season, the skins are very difficult to get dried, and it is then recommended that, if possible, they should be pickled in brine. Failing alum, wood-ashes, or even salt, may be employed for dried skins.

In addition to the skin, it is essential that the skull, and, if possible, the bones of the limbs, should be preserved as complete as possible. The flesh should be cut from the skull and the brain taken out through the natural hole at the back. The bones should be soaked for a few hours in water, after which they may be dried in the sun. In hot, dry climates the teeth should be coated with wax in order to prevent their splitting. A wash of turpentine over the skulls and other bones will prevent the ravages of insects.

It is important that the Museum should acquire series of skins of all the larger species of Mammals as a study-collection, and also a duplicate set for future mounting. Skins of all species, whether rare or common, will therefore be acceptable, and no specimens, if properly labelled and provided with their own skulls, can fail to be of present or future use.

In addition to these, skins and skeletons or skulls of well-established breeds of Domesticated Mammals from all parts of the world are required.

II.—Small Mammals.

1.—With the freshly killed carcass before you, write the label. This should bear on the front a current number,* the date, sex,

* Current numbers should be irrespective of species, and should run on continuously throughout the life of the collector, not commencing afresh at each trip.

locality, altitude above sea (in metres or feet), and your name, with title if any; on the back the following measurements in millimetres, taken in the flesh: length of (1) head and body; (2) tail without end-hairs; (3) hind foot without claws; and (4) ear, from notch at base to tip. In the case of the first two measurements, the body should be straightened out as much as possible, and the tail bent upwards at a sharp angle. The measurements should then be taken from the point of the angle (see illustrations on page 15). The label should also have on its

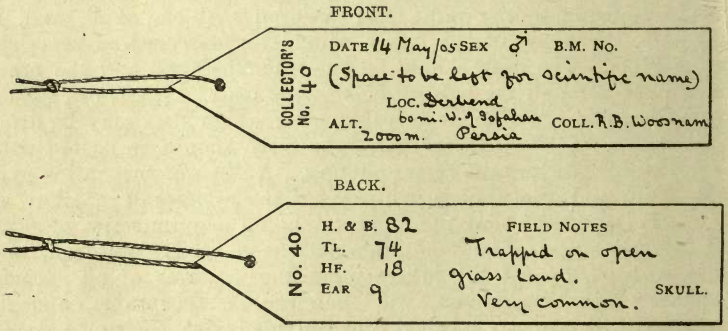

FIG. 2.—EXAMPLE OF LABEL.

back any notes that may strike you about the habits of the animal, its native name, or the character of the locality; and it is a convenience if the current number be repeated on the back, near the thread-hole.

It is important that the positions of the different items, the method of writing dates, and the direction of the writing (away from the thread) should be exactly as in the example, so that skins from different sources may all be similarly labelled.

2.—Open the skin by cutting up the belly from the anus to the hinder end of the breast-bone; first push one and then the other knee through the opening, and cut through the legs at the knee-joints, leaving the shin-bones in the skin; clear off the chief muscles

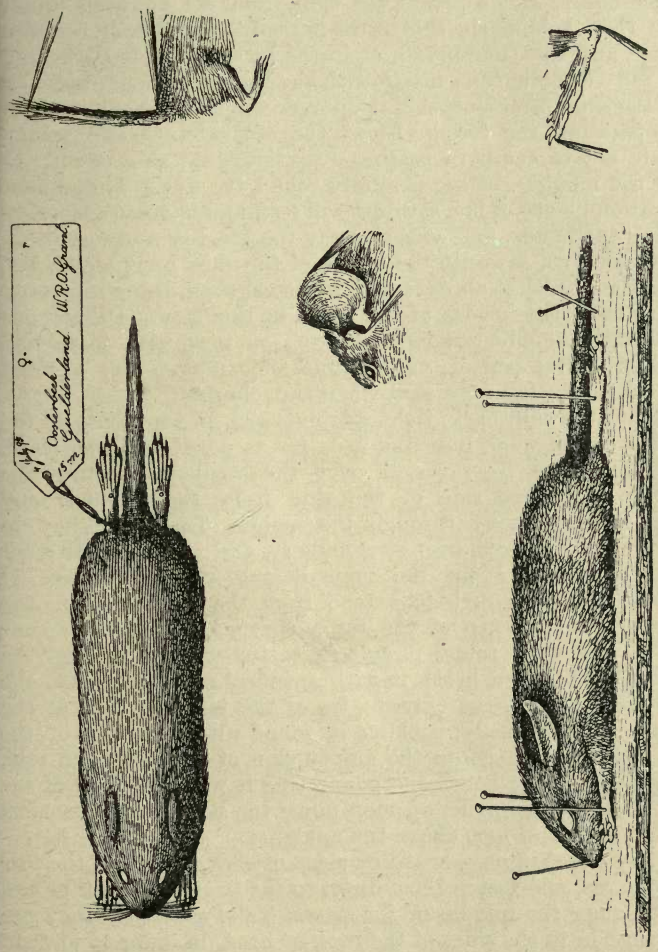

FIG. 3.—COMPLETED SKIN, SKIN ON SETTING BOARD, AND METHODS OF TAKING MEASUREMENTS. (See p. 14.)

of the leg-bones, and separate the skin from the body all round the tail; then, holding the skin at the base of the tail firmly between the finger- and the thumb-nail, or in the fork of a cleft stick, pull out the tail-vertebræ from inside with the forceps; then, gradually turning the skin inside-out, skin it up over the body, shoulders, and head, separating the fore-limbs at the elbow-joint, and taking great care not to cut it in passing over the eyes; skin it entirely off over the mouth, cutting carefully round the lips. Throughout the operation plenty of fine sawdust will be found of great assistance in keeping the hands, and consequently the fur, dry and unsoiled.

3.—Clean with sawdust the inside of the skin from blood, fat, etc., and then brush it all over with arsenical soap, being especially careful to treat the insides of the limbs in this way. Do not put any poison, especially powdered arsenic, on the outer, furry side of the skins. But pepper, naphthaline, or camphor may be used to keep off moths from the skin when travelling.

4.—Turn the skin back, right side out, and fill the cavity of the body with cotton-wool, inserting it as far as possible in one piece. Or the skin may be reversed over the wool by putting the forceps up the furry side of the skin from the tail-end, and grasping the wool-body through the mouth. Take care just to fill out the skin without over-stretching it, and try to get all your skins filled out to about the same degree. Take a piece of straight wire long enough to extend from the front end of the belly-opening to the tip of the tail; sharpen, if necessary, one end of it, and wind round it enough cotton-wool to fill out the skin of the tail; then brush it with arsenical soap, and push the pointed end down to the extreme tip of the tail-skin, and fit the near end into the belly, packing it round with the wool of the body. Put some wool into the empty skin of the arms and legs, winding it round the bones and connecting it with the wool of the body. Then stitch up the opening down the belly. Tie the label on to the right hind foot above the ankle.

5.—Lay the skin on a board or piece of cork, draw out the fore paws forwards, and fasten them down to the board by a pin passed boldly through the middle of the paw. Take care that they are pinned close in to the sides of the neck or head, in order to prevent

their claws catching in other skins when all are packed together in boxes. Similarly, pin back, *soles downwards*, the hind feet by the sides of the tail. It is of considerable importance that neither fore nor hind feet should project laterally outwards, and that they should not curl up in drying, and that the fingers and toes should be kept parallel, not spread out sideways.

6.—Re-measure the head and body, and if there is any discrepancy between their length and that already recorded on the label, try and reduce it by compressing or pulling out the skin until the two correspond. In a well-prepared skin the measurements should be the same before and after skinning. As the skin dries, try to get the face to assume as natural a shape as possible. The ears in Foxes, Hares, Rats, and Mice may be neatly folded backwards; in Bats, Squirrels, and other animals they should stand up in an erect position.

7.—Disarticulate the skull from the trunk, label it with *your initials*, and the corresponding number to that on the skin, and then let it dry. In a dry climate this may be done almost without any cleaning; and even in a wet one, if the skull be dropped into some sawdust artificially dried, little cleaning need be done: in any case the tongue should always be left in to protect the palate-bones. In a general way try to do as little to the skull as the climate will permit, but, of course, it must not be allowed to become rotten. Drying naturally or artificially is the best, and arsenic or other chemicals should not be put on it, insects being kept off by the use of naphthaline or other disinfectant. Fly-blown skulls should not be dropped into the same box with other drying skulls, nor should fresh skulls be shut into tightly closed boxes. A convenient way to dry the skulls is to place them, immediately after they have been taken out and labelled, in a muslin bag with a little sawdust, and then to hang the bag in the air or sun, or before the fire, so as to dry them without exposing them to the attacks of blow-flies.

8.—Pack the skins up carefully in small boxes when they are dry, in layers, with enough wool between them to prevent their shaking about. Do not roll them up separately in paper.

It is a good plan to have with you an ordinary cork-lined

insect-box, in which the pieces of cork can be pinned for travelling. When the skins are partly dry, they can be taken off the separate pieces of cork, and pinned close together in the box, where they can safely travel and dry at the same time.

9.—Bats should be skinned like other animals, but the limbs are separated at the shoulders and hip-joints instead of at the elbows and knees. They are also pinned down in the usual way, the pins running through the wrist-joints and the hind feet. The wings *should not be spread out*, but should be folded up on each side of the body in such a way as not to hide the fur of the belly. The thumbs should be made to point inwards or backwards, not outwards. The hind legs may be spread sufficiently to stretch the membrane between them, and then their breadth taken as a guide for the breadth of the wings when folded. Some specimens of each species should also, if possible, be preserved in spirit (not in formalin).

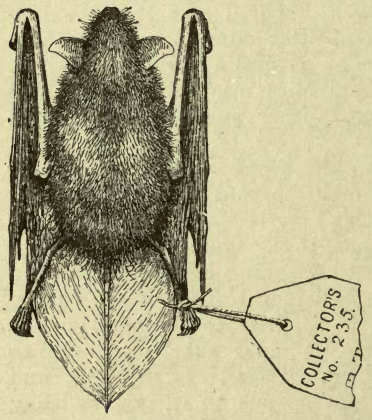

Fig. 4.—Skin of Bat.

The skinning of larger animals must necessarily be somewhat different from the above; but the labelling and make-up of skins should be as described, except that when the combined lengths of body and tail exceed thirty-nine inches the tail should be bent round sideways on itself or along the side of the body.

WANTED, generally, all small Mammals, *however common—i.e.*, Squirrels, Rats, Mice, Shrews, Moles, Bats, Weasels, Stoats, etc., etc.—but Rats and Mice caught in houses in towns are not wanted. Do not be afraid of sending too many of the same sort, if carefully prepared and labelled as above described. This direction, however, would necessarily be modified in the case of

specimens collected *for sale*. Series of skins representing the different seasons are always of interest.

Small Mammals are to be obtained chiefly by setting traps in likely places, runs and mouse-holes being specially looked for. A stock of small metal traps should be taken out by the collector, who should also look out for effective native traps. Pitfall-traps, made out of glass or metal jars sunk in flush with the ground, are also very often successful.

III.—Parasites of Vertebrates.

Collectors may do good service by preserving the parasites, both external and internal, of Mammals. In some cases these parasites have a practical importance which can hardly be overestimated, since they act as the carriers of disease to man or domestic animals. The more important external parasites are Ticks and a few other Arachnids (pp. 127, 191), and Fleas and other Insects (pp. 68, 78, 191). A considerable number of Worms (p. 193) are found as internal parasites. For methods of preservation, which, in the case of the Worms, should be carried out with special care, *see* the pages cited above.

Whales and Dolphins often bear interesting Crustacea on various parts of the body, particularly where the skin is folded or wrinkled. The collection of their internal parasites (various kinds of worms) is specially desirable.

Parasites from other classes of Vertebrates, Birds, Reptiles, Batrachians and Fishes, are equally acceptable. In the case of Fishes, the external parasites are principally Crustacea (pp. 154, 192), which are found attached to the gills, inside the mouth, under the fins or on various other parts of the skin. Internal parasites are of common occurrence in all these groups.

Mammals, Part II.

SKELETONS, with Special Notes on the Collection of Specimens of CETACEA.

I.—Mammals other than Cetacea.

1. Preliminary Hints.

The preparation of skeletons in the field should go no further than the removal of sufficient flesh to ensure freedom from putrefaction. Every care should be taken to leave the bones naturally attached to each other, and with this object in view it will be sufficient, after removing the internal organs—heart, lungs, liver, intestines and so on—to cut the flesh roughly from the body and legs, and to expose the carcass thus cleaned to the sun. In small animals the limbs should not be separated from the rest of the skeleton. In those of larger size, the fore legs should be removed *with* the blade-bone, and the hind legs should be detached at the hip-joint. If not too large, the limbs should then be tied firmly to the rest of the skeleton. This is most important, especially where several skeletons are packed in the same case. To save space and to facilitate packing, each limb should be folded on itself. In very large skeletons it may be necessary to separate the fore leg from the shoulder-blade, and even to subdivide the limbs; care being taken to cut the principal joints without injuring the bones. The tail should be turned forwards so as to lie inside the body. On no account should any preservative be used.

If the skin of the animal is being prepared as well as the

skeleton, the bones of the feet should be left in the skin, unless the specimen is of large size. If the entire skin is not being kept, it may be desirable to leave the hands and feet covered by skin, in order to avoid the loss of any of the small bones, and to prevent those of different limbs from being mixed. If these bones are brought back loose, it is impossible to arrange some of them (particularly those of the fingers and toes) with any certainty that they are being placed in their proper order. Whenever possible, skeletons should be secured of male, female and young animals. In every case in which the species is not definitely known, care should be taken to attach to the skeleton a characteristic piece of the skin, showing the colour of its fur or wool. This must belong to the particular individual whose skeleton is being prepared. It is very desirable to indicate what species the skeleton probably belongs to by reference to the collector's numbers of the skins sent at the same time. In all cases, a label recording the precise locality in which the animal was killed, with altitude and date, and the sex of the specimen, should be tied to the bones. If the skeleton is sent in more than one piece, each part should be separately labelled, so that there can be no possibility of mixing the parts of different individuals.

2. More Detailed Instructions.

After the removal of the skin, the abdomen should be cut open from the end of the breast-bone to the hip-girdle; and from the cavity thus exposed the whole of the contents should be removed. After the intestines, liver and stomach have been taken out, the "midriff," at the front end of the cavity, should be cut through to allow of the removal of the heart and lungs. The gullet and windpipe can be pulled out from the front of the neck. Special care must be taken to avoid injury to the hyoid bones or tongue-bones, which generally run from the region of each ear towards the lower surface of the larynx (at the front end of the windpipe) and back of the tongue, where the two series are joined by means of a bone in the middle line.

All superfluous flesh should next be cut away from the limbs,

trunk and head. In small animals there is no need to remove any flesh from the ribs. Particular care should be taken, throughout the operation, to avoid cutting or breaking any of the bones.

The skull should be severed at the joint which connects it with the neck, and not by chopping through the neck-bones. In very small animals, however, it may be left in place. After the separation of the skull, as much as possible of the brain should be removed by stirring up the contents of the brain-case, through the opening at the back of the skull, with a blunt stick. This process will be facilitated by pouring water into the brain-case. The top of the skull should not be sawn off, and no attempt should be made to clean out the whole of the brain from the more inaccessible regions of the skull, since injury may easily be caused to the bones lining the brain-case if too much cleaning is attempted. Unless the animal is of large size, the tongue may be left to dry up, and the tongue-bones already alluded to will thus be retained in place.

If time permits, and there is an abundance of water at hand, it is well to remove the blood from the roughly cleaned skeleton by soaking it for a day or two in water, preferably running water. For safety's sake the carcass should be placed in a basket, or tied up in a sack. Special precautions may be required in places where there are predaceous animals such as Crocodiles or other aquatic carnivorous forms. But where the climate is unfavourable, or water scarce, this soaking may be dispensed with.

The further treatment of the skeleton must depend a good deal on the size of the animal. If it is small, there will be no great difficulty in getting it properly dried, and it can then be packed in one piece, taking the precaution of turning the end of the tail in so as to be protected by the backbone and ribs. If it is large, the limbs may be detached separately; removing the shoulder-blade, which carries the fore limb, from the ribs, and dividing each hind limb from the pelvis or hip at the articulation of the thigh-bone with that part.

It may further be necessary to cut the backbone into sections of convenient size for packing. This division can be effected at any point, provided it is made in such a way as to avoid injuring

the vertebrae or constituent bones of the backbone. It will be found quite easy to separate two vertebrae from one another if the knife is inserted first on the lower side (that which comes nearest the cavity of the thorax or abdomen). The two parts of the backbone on either side of the cut are then bent upwards, away from the cut. The following may be indicated as convenient points for dividing the backbone :—junction of neck and thorax ; junction of thorax and abdomen. If the cuts are made as above, the thorax, consisting of vertebral column, ribs and breast-bone, may be packed so as to contain the skull and some of the other parts of the skeleton.

The rough skeleton, or the parts into which it has been divided, should next be hung up in a dry place, where there is a free current of air, and protected, if necessary, from attack by predaceous animals. Before the parts become quite dry it will be advisable to fold them in a position convenient for packing.

When thoroughly dry, the skeletons may be packed in boxes. Sawdust, especially pine sawdust, may conveniently be used, as it absorbs moisture and prevents any unpleasant smell. Each skeleton should be wrapped separately in paper or canvas, to avoid the danger of getting its parts mixed with those of other specimens, which might happen, for instance, in a skeleton attacked by beetles on the way home. This precaution is specially important for skeletons of small size ; but in every case the greatest care should be taken to label and pack the parts in such a way that no admixture of this kind is possible. The value of a specimen is destroyed if there is any suspicion that all the bones may not be those of a single individual.

The skin of an animal prepared for permanent preservation should always be accompanied by *its own* skull, even if the rest of the skeleton has not been kept. But a skull by itself is always worth preserving if properly labelled with locality and other data. Sex and external measurements (*see* pp. 13, 14) may be usefully recorded on the label.

In the males of Monkeys, Carnivora and Rodents there may be present a loose separate bone in the penis, which should also be preserved, dried and fastened to the rest of the skeleton.

And in some few animals, notably the Cats, the collar-bone is rudimentary, and care should be taken that it is not thrown away if the limbs are taken off.

II.—Cetacea (Whales, Dolphins and Porpoises).

The collection of Cetacea offers special difficulties, but useful work may be done if advantage is taken of suitable opportunities. Whales and Dolphins are not infrequently stranded on the coast, and smaller kinds are sometimes caught in fishermen's nets.

No satisfactory way of dealing with the skins of these animals is known, and it is accordingly not desirable to waste time in preparing skins which can neither be stuffed nor made much use of in any other way. The skeleton is the part which is most valuable from a scientific point of view, but it is important to have a record of the external appearance of the animal from which it was derived.

In collecting Cetacea, the first thing to do with any specimen is to make certain measurements and notes on its external appearance.

The more important measurements to be taken are those indicated in Fig. 5, B ; but the length of the paddle or flipper (fore limb), measured along its lower border, and the distance between the vent and the opening of the reproductive organs should also be recorded.

It should be ascertained whether the mouth contains " Whale-bone " (baleen) or teeth. In the former case, note the number of blades of baleen * which grow on each side of the palate (Fig. 6), and, if possible, the length and breadth of the largest blade. The colour of the baleen-plates and of the hairs which fringe their edges turned towards the cavity of the mouth should be carefully recorded, and it should be noted whether all the blades are of

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* The number of the larger blades—those which constitute the main series—should alone be counted.

the same colour. The characters of the baleen are particularly important in distinguishing the species of the Whalebone Whales. In Whales of this kind, note further whether the skin of the throat and lower part of the thorax is marked by a number of deep longitudinal grooves (Fig. 6).

If teeth are present, state their number, on each side of each jaw, recording also their average diameter at the base, their length

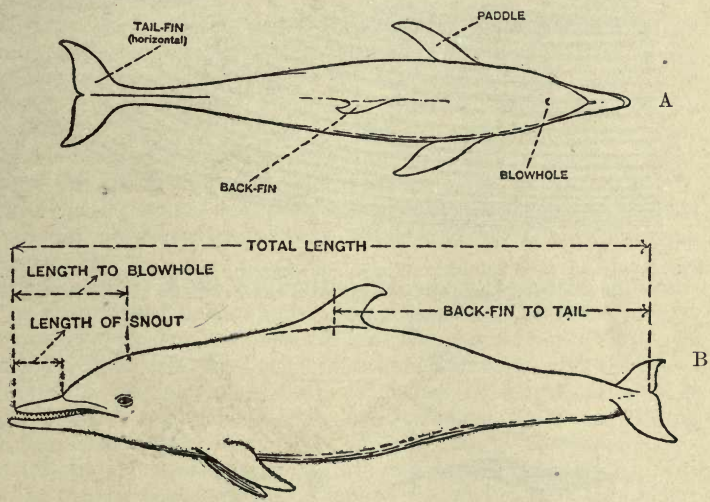

FIG. 5.—A, Back view, and B, side view of a Dolphin (a Toothed Whale), to show how the principal measurements should be taken.

and their shape. In several kinds of Whale the teeth are greatly reduced in number, even to a single pair (Fig. 7); or one or more pairs of teeth may be present beneath the gum, usually at the extreme front or near the angle of the mouth, the animal then appearing toothless. In Whales with only a few teeth or none visible, note whether there are a pair of longitudinal grooves on the skin of the lower side of the throat (Fig. 7).

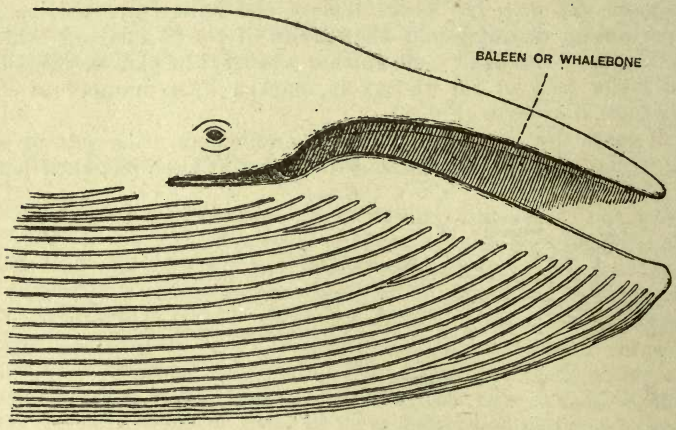

FIG. 6.—Head of Whalebone Whale, showing the whalebone or "baleen" of one side in place and the grooves, characteristic of the Rorquals, on the skin of the throat.

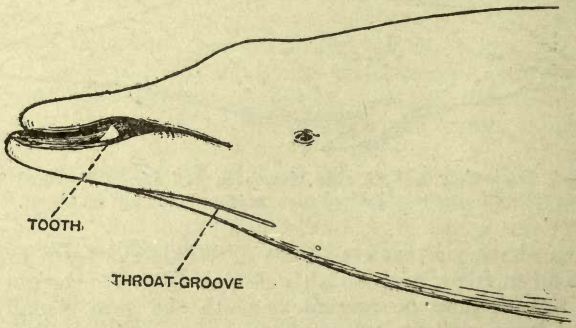

FIG. 7.—Head of a male Sowerby's Whale, in which only two teeth are present, one on each side of the lower jaw. In the females and young of this species, the teeth are concealed beneath the gum, and none are visible.

The shape of the head should be described, and a sketch made of the profile (side view). In many kinds of Dolphin, the front part of the upper jaw is sharply marked off from the rest of the head (Fig. 5). The length of this snout or "beak" should be noted.

The external coloration should be recorded, special attention being given to the distribution of the dark and light colours respectively.

A large Whale is too bulky an object to be dealt with by an unaided collector. It will thus be sufficient to note the above particulars and to secure a blade of baleen or a tooth, as the case may be. If a whaling station is visited, there may be an opportunity of securing some of the remarkable shell-like ear-bones which are readily separated from the skull in Cetacea. The sternum (breast-bone) and the rudimentary pelvic bones (see below) are also parts which are particularly worth collecting. Special care should be taken to ascertain what kind of Whale each such bone belonged to.

The skeletons of Whales or Dolphins are prepared in the same way as those of other Mammals. In opening the abdominal cavity, to remove the viscera, look specially for the pelvic bones (Fig. 8, *p*), which represent the hip-bones of other Mammals. These are a pair of separate bones, perhaps six inches in length in a large Dolphin, which are embedded in the flesh near the vent, one on each side of that aperture. They are not always easy to find, as they are not articulated with any other part of the skeleton. The hyoid or tongue-bones should be looked for, as in other Mammals; but they offer little difficulty, as they are of considerable size.

In commencing operations, the two lobes or flukes of the tail and the back-fin may be cut off, as they contain no part of the skeleton. It is generally advisable to cut through the blubber, and to remove it in strips, starting from the tail and working forwards along the body to the head.

The paddles or flippers should be cut off at the shoulder-joint; or, in the case of the smaller species, each shoulder-blade, with the flipper attached, may be removed from the body in one operation. The flippers should in all cases be preserved entire, no attempt being

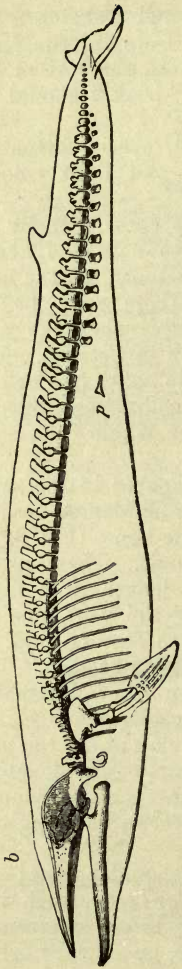

FIG. 8.—Skeleton and outline of the Common Rorqual or Fin-Whale (a Whalebone Whale). *b*, Position of blow-holes; *p*, pelvic bone. The tongue-bones are indicated, just below the lower jaw. The breast-bone is not represented. About $\frac{1}{156}$ natural size.

made to remove their skin or blubber or to separate the bones supporting them. They need practically no preparation, and may be left to dry up as far as their oily nature permits them to do so. Any ordinary disinfectant may be applied to their surface occasionally if signs of putrefaction should be noticed.

Complete paddles, with the skin intact, of the following species of the larger Whales are specially wanted: — the Greenland Right Whale (*Balaena mysticetus*), the Pacific Grey Whale (*Rhachianectes glaucus*), and the Southern Pigmy Right Whale (*Neobalaena marginata*).

After the removal of the blubber and paddles or flippers, and after the pelvic bones have been taken out, the intestines and other viscera may be removed, and the flesh cut away from the bones, in much the same way as in the case of any other Mammal. The skull should be carefully disarticulated and the brain removed through the hole at its base, the flesh being cut away from the head so far as this can be done without injuring the bones. The backbone should be divided into sections, if necessary, the divisions recommended on p. 23 being equally suitable for Cetacea. In the case of large specimens it may be necessary to separate the ribs from one another. In doing this, avoid injury

to the breast-bone, and disarticulate each rib from the backbone in such a way as not to damage it.

Many species of Cetacea have been described on the evidence of skulls or other bones, no information as to the external appearance of the living animals having been given. In other cases the reverse has been true, species having been described from their external characters without reference to the bones. It is accordingly specially important to make sketches or to take photographs of the external appearance of a Cetacean before preparing its skeleton; and work of this kind may be important in helping to decide difficult questions relating to the species. It is particularly desirable to obtain information, based on actual specimens, with regard to the species of Dolphin which inhabit the open sea, far from land.

If the entire skeleton is not prepared, the skull and the two flippers (complete, with skin intact) should be secured, the external characters of the living animal being noted and sketched.

Every specimen should be carefully labelled with locality, date of capture, total length of specimen and sex. The male organ of Cetacea can be completely retracted, and when it is thus concealed it may be possible to mistake a male for a female. The female may be recognized, as a rule, by the occurrence of a longitudinal slit in the skin, on each side of the reproductive opening, this slit usually concealing the retracted nipple. The length of the interval between the vent and the opening of the reproductive organs should be stated in the measurements of the fresh specimen; and this information will assist in determining the sex.

It has been stated that the yellow slime sometimes found on the skin of whales consists of large numbers of the microscopic plants known as Diatoms (*see* p. 168). Samples of this slime preserved in 10 per cent. formalin (*see* p. 131) are specially wanted. A better method is to add to 250 cc. of the material in sea-water 10 cc. of strong Flemming's solution (15 volumes of 1 per cent. chromic acid, 4 volumes of 2 per cent. osmic acid, and 1 volume of glacial acetic), and to store in a stoppered bottle. The species of whale and the part of the skin from which the sample is taken should be noted.

Birds and their Eggs.

I.—Instructions for the Preservation of the Skins of Birds.

General Remarks.

A little patience and a little practice are all that is required to make a good skin of a bird. Also it should be remembered that no more time is wanted to make a *good* skin than a *bad* one. Thus it should be the aim of every naturalist to attain perfection in the art of preparing specimens; and, after all, this is easy.

Tools.—The skinning of a bird demands but few tools. Many collectors require a penknife only; but the tyro should be provided at least with a sharp knife or scalpel, a pair of stout nail-scissors, as well as some arsenical soap, bleached wool, tow, and a sharp-pointed awl or darning-needle.

The knife is needed for making the first incision, and it is useful for scraping off fat from the skin. The nail-scissors are wanted for cutting through the flesh, and severing the tendons and the bones at their joints. The awl or darning-needle is useful for re-arranging disordered plumage.

Preservatives, etc.—Arsenical soap is the best preservative for general use, as skins dressed with it retain much of their natural elasticity, and can at any time be mounted. Powdered arsenic is largely used, especially by American naturalists, and is useful in a damp climate, as it dries the skins quickly. The disadvantages of employing it are, firstly, the danger in carrying it about, and secondly, that specimens so preserved become shrunken and brittle, and are never so easy to mount. Alum and pepper do not keep off the attacks of moths and beetles, and for various reasons are not to be recommended. Carbolized specimens are all but worthless,

as they fall to pieces after some time. Corrosive sublimate is frequently recommended as a preservative, but skins so prepared become exceedingly brittle, and after a lapse of years scarcely bear handling, ultimately falling to pieces. Arsenical soap is undoubtedly the best preservative for bird-skins.

Fine bleached cotton-wool is necessary for the filling in of the eye-sockets of the specimens. Nothing conduces more to the neat appearance of a properly prepared skin of a bird than the aspect of the head and eyes. For small birds there is nothing better than cotton-wool for the filling out of the skin. Ordinary cotton-wadding is also useful for wrapping round the skins after they have been made up. It helps to keep the skin in good shape and to dry it quickly.

Tow is useful for filling out skins of larger birds ; and, if possible, the neck should always be made of tow, instead of wool, for, if the specimen should ever be required for mounting, the wires of the taxidermist can easily be worked through a neck made of tow, whereas wool is impervious.

Fine white sawdust should always be handy for sprinkling on the body of the bird while it is being skinned, and some plaster of Paris is an almost indispensable adjunct in skinning wading and swimming birds, which are often covered with fat. As, however, these materials cannot always be procured in the tropics, dry sand may be used as a substitute, and, in an emergency, tobacco-ash, or even dry earth, can be made available. Care must be taken to prevent the edges of the feathers becoming soiled by contact with the body of the bird as it is being taken out. Little wisps of cotton-wool should be at hand, to interpose along the bases of the feathers while the skin is removed, as they serve to keep the feathers back and to prevent them touching the flesh of the body. With a little practice the collector will find that he knows instinctively what feathers will be affected by his action as he removes the skin from the different parts of the body, and his fingers will naturally intervene between the feathers and the flesh.

Commencement of Operations.

The subjoined directions refer specially to the preparation of skins of birds not larger than a Thrush.

The collector should begin operations by seeing that all his necessary appliances are at hand—fine white sawdust or dry sand, tow, wool, nail-scissors, and knife. Some taxidermists begin by plugging the nostrils. This should be avoided, if possible, as the shape of the nostrils and their adjacent parts should be left undisturbed. Many genera of birds are characterized by the shape of the nostrils and their bristles, and every care should be taken to keep these exactly as they are in life. If, as is often the case, there is a discharge of mucus from the nostrils, it should be carefully soaked up with wool before the skinning begins; but no more than a tiny wisp of wool should be inserted, care being taken not to disturb the actual shape of the aperture. A far better way of preventing any discharge during the preparation of the bird's skin is to open the bill and, while plugging the mouth, insert a tiny piece of wool into the cleft in its roof.

The mouth must *always* be carefully filled with cotton-wool before commencing to skin.

Any shot-wounds should be either dusted with sand or lightly plugged with wool; but it should be remembered that bloodstains are more easily removed by taxidermists in England than by the collector in the field, and that it is therefore better not to try to clean skins on the spot. Any discharge from the nostrils must, however, be looked after carefully, as it spoils the skin when the head is being turned back, and the stain of mucus cannot be eradicated. If the eyes have been damaged, it is well to sprinkle them with plaster of Paris or dry sand, and to plug them under the eyelids with a tiny wisp of cotton-wool before commencing.

Removal and Preparation of the Skin.

The next objects are to remove the skin from the body and to restore it to its natural appearance. Through the incision now to be made, the whole of the bird's body has to be drawn out, and this should be done as neatly and expeditiously as possible. Many taxidermists make the incision down the side of the body under one wing. This has the advantage of preserving the feathers of the breast and abdomen intact, but there is also a risk of making the skin lop-sided. If the incision be made under the left wing, the

joints should be cut through in the following order :—left shoulder, neck, right shoulder, left thigh, right thigh, tail ; or left thigh, tail, right thigh. An excellent way, especially with Game-birds, is to make an incision from the vent on either side to the upper edge of the thigh. By this means a triangular flap is made of the abdominal skin, which falls back into place after the body has been taken out, and the feathers of the breast are not disturbed at all. Many taxidermists prefer the plan indicated in fig. 9, and explained beneath the figure. Others cut the bird open along the keel of the breast-bone to the top of the abdomen. This cut should not be carried far beyond the front end of the keel, or the skin will tear across the sides while the neck is being removed, and the damage will be irreparable. The skin is next pushed back till the left shoulder is exposed : this must be divided at the *shoulder-joint*, the humeral bone being *always* left with the wing (see fig. 10). Then the skin must be carefully pushed back by the fingers and thumb-nails till the neck is exposed. This must be cut through with the nail-scissors, care being taken not to make a hole with their sharp points in the skin below the neck ; the right wing must then be attacked, and also severed at the shoulder. All this time, with each motion of the fingers, the feathers of the breast will be exposed to the risk of being soiled by the moist surface of the body. It is, therefore, necessary to have some sawdust or sand handy to sprinkle over the raw flesh as it becomes exposed ; and if this be not available, a wisp of wool laid along the bases of the feathers will keep them back in a most unexpected way ; but, as already stated, after a few attempts at skinning a bird, the fingers will be found to interpose by instinct, and to prevent the feathers from becoming soiled by contact with the flesh.

The two wing-joints and the neck being severed from the trunk, the skin can easily be pushed off the back of the bird till by degrees the thigh-bones are approached. In many birds—such as Thrushes, for instance—the skin is very firmly attached to the lower back, and any attempt to hurry will end in splitting the skin right across. Although an accident of this sort may not ultimately destroy the appearance of the skin, it is difficult to restore the natural set of the feathers of the upper surface. As the skin is pushed off the lower

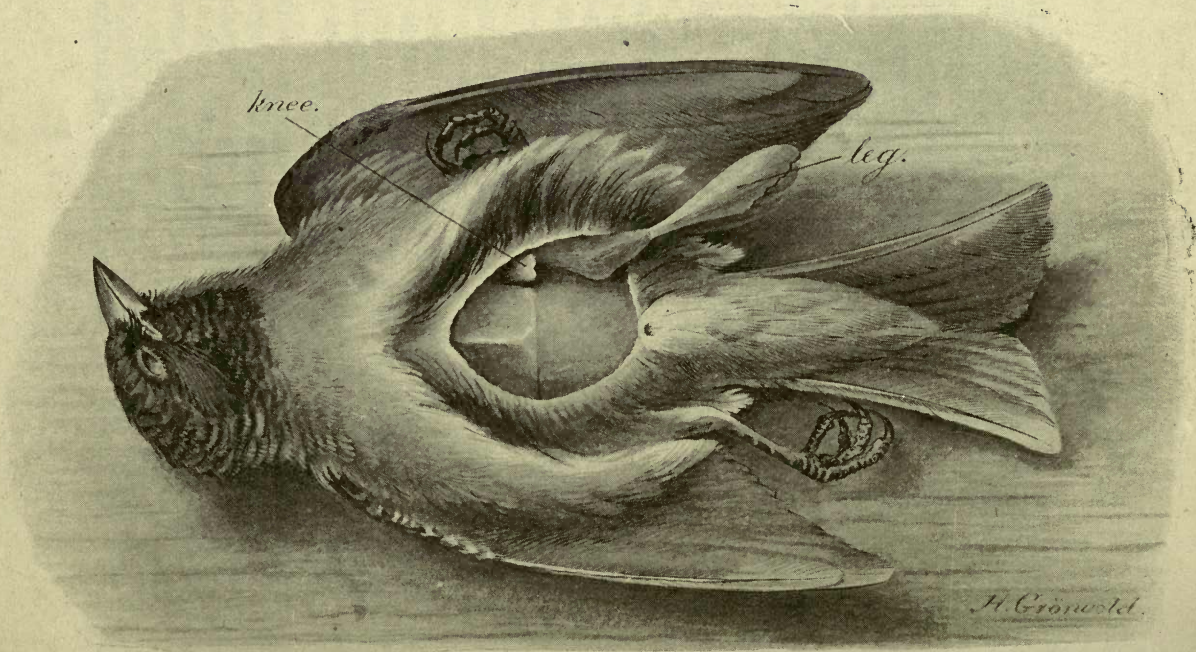

FIG. 9.—In the method here indicated, an incision is made from the lower half of the keel of the breast-bone to the vent. The skin is then gently pushed from the body-wall till the knee-joint is exposed. This is severed, and the leg is pulled back within the skin. After the two legs have been thus treated, the tail-bone is cut through and the skin is separated from the body, working towards the head. The wings are detached as soon as they are reached, and the neck is severed at the base of the skull. The method of cleaning the skin is described in the following pages.

back and thighs, the latter come prominently into view, and they should be severed at the knee-joint (*see* fig. 9). The tibial bone itself, when not broken by a shot, should always be kept in the skin, as it becomes a support for the legs when the skin is made up. By the severance of first one thigh and then the other, nothing is left to cut but the tail; and when the skin has been pulled down sufficiently to expose the oil-gland, it may be detached by a sharp cut above the latter. It should be noted that a good deal of flesh can be left on the root of the tail without damage to the skin, provided that it be thoroughly *well dressed with arsenical soap.* It is a maxim in the preservation of mammals and birds that all fat should be removed from the skin as far as possible; but this requires great care, and the arsenical soap will account for any small fragments of fat which have to be left.

It now remains to remove the flesh from the legs and wings, and to turn the head and neck inside out. By pushing the leg up from the outside, the flesh is soon exposed along the shaft of the leg-bone, and is easily removed with the tendons. A wisp of cotton or tow is wrapped round the bone, as a substitute for the flesh, and the legs are then drawn back to their natural position. The wings are then dealt with: the flesh is removed from the humerus, and by a certain amount of pressure the skin which conceals the flesh of the other wing-bones can be pushed back, when the flesh which lies between them must be cut out as far as possible. In the case of large birds it will be found best to make an incision along the wing-coverts from *the under side of the wing.* The flesh can thus easily be removed, and the cut is not noticed when the skin is made up and the wings folded close to the body. The wing-bones and the skin of the wing should be *thoroughly* dressed with arsenical soap, as any flesh remaining is apt to decay, and then the wing-coverts and the quills fall out. In small birds there is not so much risk of this misfortune, but large birds are often spoilt through inattention to these details.

The preparation of the head is usually considered by beginners to be very difficult, but in reality it is quite easy. Special care should be taken not to stretch the neck, as a skin in this state is always ugly; and the neck, when once unduly stretched, can never be got back to its proper length. By gently forcing the skin of the head

back from the outside, the skull is gradually exposed ; and, except in the case of very small birds, it is necessary to skin down to the base of the bill. When the skin has been pushed back as far as the eyeballs, it will be found to be connected firmly with the ear (*see* fig. 10). This must be detached, on each side, by placing the point of the knife *under* the tightly stretched skin and carefully lifting it out of the tube (the aperture of the ear) to which it is attached. The next difficulty is the eyelid. Still stretching the skin towards the bill, make a light cross-cut behind the point of attachment above the eyeball, taking care not to cut into the latter. This cut will partially separate the eyelid from the eye, and a second upward cut from in front backwards completes the operation. It is very important to preserve the eyelid intact, as nothing spoils the appearance of a skin so much as a torn or damaged eyelid. Each eyeball should be removed from its orbit by slipping the knife under it and severing the optic nerve and muscles by which it is kept in place, holding it meanwhile between the knife and the thumb. The brain may next be scooped out through an opening made by cutting a triangular hole through the back of the skull and extending it forwards along part of its floor. A portion of the head and the tongue are removed during this operation, and pieces of flesh covering any parts of the skull which are left in the skin should also be scraped away. The skull and the skin of the body should then be carefully dressed everywhere with arsenical soap, and the head turned back by means of a little gentle manipulation. Great care must be taken not to stretch the skin of the neck in pulling the head back into position ; and the head and neck should always be drawn *back towards* the body before the skin is made up. The skin may now be made up in the following way :—Opening the bill, small tufts of pure white bleached wool, which fill out the contour of each eye in turn, are put into the eye-sockets, through the hole cut in the palate. This method has the advantage of filling out the *eyelid*, and bringing into relief any eyebrow which may be a specific feature of the bird—certainly a great advantage, and conducing to the neat appearance of the skin when finished. A small stick, one end of which is sharply pointed, is now selected, and its length adjusted to reach from the skull of the bird to a

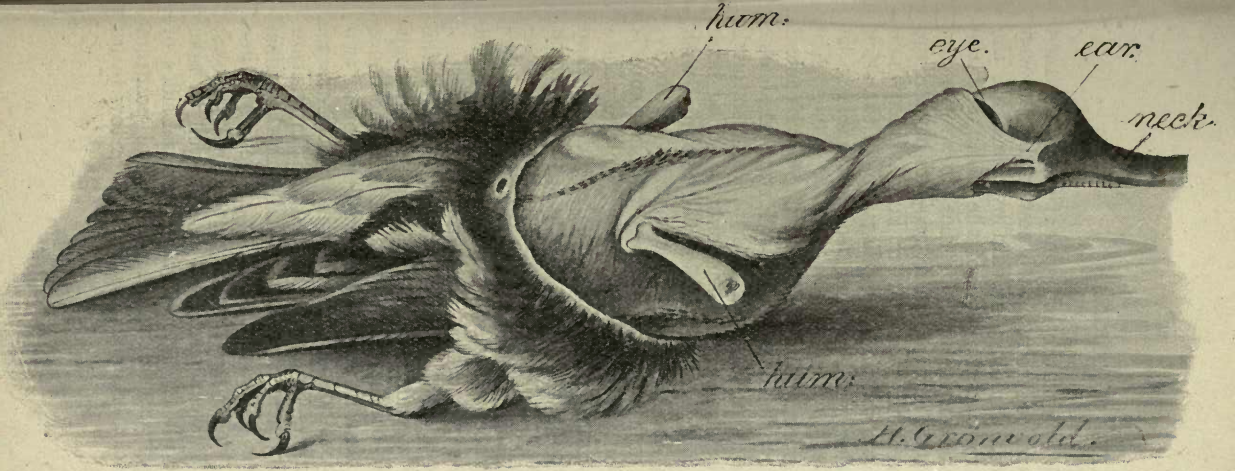

FIG. 10.—Partially skinned bird, showing the appearance of the skin, now turned inside out. The body has been cut off at the base of the neck. Note the skin still attached to the aperture of the ear, and the position of the eye. *hum* = humerus, or arm-bone.

FIG. 11.—A completed "skin." This is to show the appearance which a bird should have after the removal of the body and the substitution of stuffing materials. Note the position of the beak and legs, and the method of folding the wings.

point an inch to two inches beyond the tail-bone, the part destined to form the neck being wrapped round with tow and then well covered with arsenical soap. Holding the skin by the beak, the artificial neck is then coaxed up the skin of the neck, and the sharp point firmly imbedded in the skull of the bird, while the other end of the stick, without any tow on it, projects beyond the tail-bone. This is an excellent plan for making skins which have to be packed and transported for a long distance, as the stick serves as a support and renders the head and neck less liable to be broken in transit.

Another method of filling the eyes and the neck is to put bleached wool into the sockets as soon as the head is ready for turning back; and a neck of tow is made (a little larger than the natural one), and rammed *tightly* into the skull. Then the skin is pulled back over the artificial neck of tow, which has been well anointed with arsenical soap. By pulling the tow neck back towards the body, the head and neck can be well drawn in. Our own experience is that the method of filling out the eyes with wool from the palate has the best results, and disturbs the set of the eyelid less than that just described; but the collector will soon find out in which way he can produce the best results. In no case should the eye-socket be filled in from the *outside* after the skin of the head has been restored to its proper place, as the eyelid is sure to be destroyed or forced inwards, and the appearance of the skin will suffer.

Before filling in the body of the bird, it is very important that the set of the wings should be attended to, so that the skin may not become lop-sided. Running parallel to the two humeri (the bones of the upper arms), as the skin lies on its back, will be found two broad rough patches on the back of the bird, marking feather-tracts. If the two humeri are laid along these patches, and kept in position by a little wool placed upon them, it will be found that the wings will fall naturally into their place, and will not move. Another excellent method is to tie the wing-bones together at the elbows, leaving the natural space between them. It is also well to take a fine needle, and gently to lift the skin of the crown and sides of the head, so that the ear-coverts fall into their natural position. Then the body of the bird can be filled in with wool or tow to its

natural size, and finally wrapped round with a thin layer of cotton-wadding, and left to dry.

The two mandibles of the bill should be restored to their exact position as in life, and either tied together with cotton (*not* through the nostrils) or fastened by means of a tiny piece of cobbler's wax placed in the tip of the upper mandible.

It is advisable to unwrap all the skins the next day, to see that the feathers are smooth and the wings in position, before they are finally laid in their tin case for transmission to the Museum. To each specimen should be attached a small label with the locality, date, altitude, and sex clearly marked on one side, and, on the other, the colour of the bill, feet, and iris. The plan adopted by some collectors of attaching a number to the specimen and keeping a corresponding entry in a book is not to be recommended, as, if the number or the book gets lost, the history of the specimen is lost also.

Preparation of the Skins of Large Birds.

Large birds should be treated in exactly the same manner as described above, but greater care is necessary to remove all flesh and fat from the bones and skin, which should be carefully and thoroughly dressed with arsenical soap. As already stated, an incision should be made along the wing-coverts on the under side of the wings, and after the bones of the fore-arm (radius and ulna) have been cleaned and dressed, arsenical soap or powdered alum may, with advantage, be inserted along the incision. An incision should also be made down the tarsi and along the under surface of each toe, the sinews removed, and the bones thoroughly treated with the preservative arsenical soap.

In preparing very large birds, such as Ostriches, if not required for mounting, it is an excellent plan to inject a 5 per cent. solution of formalin by means of a syringe into the tarsi and feet. This rapidly dries them up and leaves them perfectly preserved. The labour of removing the sinews is then avoided and much time is saved.

In making up skins of birds with long necks, such as Bustards, Flamingoes, Herons, Geese, etc., the neck should be strengthened by inserting a fairly stout wire, and bent back along the breast

towards the tail. Skins made in this way are much more easily packed, and the risk of breaking their necks is avoided.

Special Treatment required for certain Birds with Large Heads.

The heads of some birds (for instance, Ducks and Woodpeckers) are too large to allow the skin of the neck to be drawn over them. In such cases the neck should be severed from the body as soon as it becomes clear that no further progress can be made without running the risk of bursting the skin. The cleaning of the head must then be left till the skin is turned back, when an incision should be made along the middle of the crown, running backwards to the nape. Through this the head may be turned out and cleaned in the usual way. As soon as it is replaced, the cut edges of the incision should be drawn together with a needle and thread, an operation which leaves no obvious trace if performed with care.

II.—How to Determine the Sex of a Bird.

The body having been removed from the skin, make a long incision down the left side with a pair of scissors, and gently force the cut edges apart; then with the handle of a scalpel displace the intestines so as to expose the wall, or rather the roof, of the cavity in which they rest. If there is much blood, wash it away with a little water, to which, if possible, should be added a little salt. All this must be done very gently; the water should be poured in, and then soaked up by a piece of sponge; or if this is not to be had in the field, drain off the water by overturning the body. Never use the sponge to rub with. As soon as the roof of the body-cavity is thoroughly exposed, the sexual organs may be sought for; but, except in the breeding-season, the search must be conducted with much care.

Attention must first be directed to an examination of the organs lying at the upper end of the kidneys, the latter being the dark red masses forming the roof of the cavity.

In the *male* will be found two egg-shaped, white, or sometimes

black, bodies, the testes (fig. 12, *t.*), lying side by side, just over the arch formed by the convergence of two large blood-vessels, which can be seen running up from the tail-end of the kidneys. In the breeding-season there can never be any doubt about these ; but in young birds, and in old ones also after the breeding-season, the

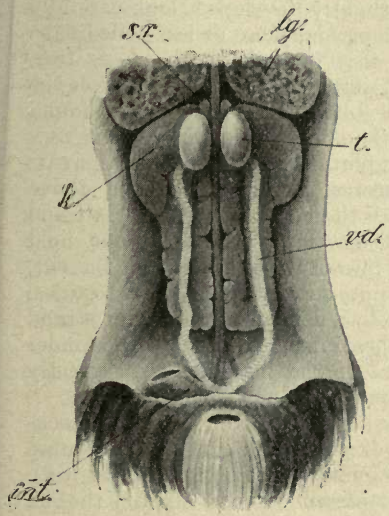

FIG. 12.—A portion of the body-cavity of a male bird exposed to show the position of the sexual organs :—*s.r.* suprarenal or adrenal ; *lg.* lung ; *t.* testis ; *k.* kidney ; *vd.* vas deferens, or sperm-duct ; *int.* intestine.

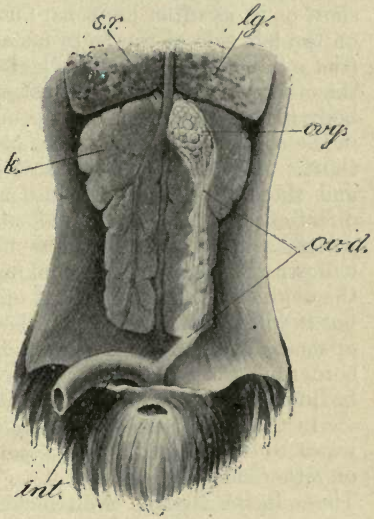

FIG. 13.—A portion of the body-cavity of a female bird exposed to show the position of the sexual organs :—*s.r.* suprarenal ; *lg.* lung ; *k.* kidney ; *ovy.* ovary ; *ov.d.* oviduct ; *int.* intestine.

testes can often hardly be made out. In such cases the greatest care must be taken lest two other small yellowish bodies, known as the " adrenals " or " suprarenals " (fig. 12, *s.r.*), lying a little higher up—at the extreme edge of the front border of the kidney—be mistaken for the testes.

In the *female*, in the breeding-season, on the left side of the body, in a position corresponding with that of the testes of the male, there will be found a large yellowish mass, made up of eggs of various sizes, from tiny granules to a full-sized yolk (fig. 13, *ovy.*). Earlier in the year the mass is granular only, and of course much smaller, sometimes extremely small. If the ovary has been destroyed by shot, or is, as often happens, but slightly developed, look carefully on the left side of the body for a long and more or less coiled tube (the oviduct), one end of which—that towards the head—is free, the other joined on to the intestine, quite close to where it leaves the body (fig. 13, *ov.d.*). A vestige of a similar small tube may be found in the corresponding position on the opposite side, but this is very short. As it is of the greatest importance to determine the sex, and there may still be some uncertainty even after the above directions have been followed, place the body in a dish of salt and water—salt is advisable, but not *absolutely* necessary—and hold it down on one side. On looking into the cavity through the cut, the oviduct will probably float up quite separate from the intestines, but it will be found to be attached, by a delicate, transparent strand or sheet of tissue, to the rib which lies immediately below the hinder border of the lung. The removal of the intestines will greatly facilitate this examination, but it must be done with care.

In the male there can generally be traced, from the testes backwards to the end of the gut, a pair of neatly and closely coiled tubes on either side of the body, of a glistening white colour (fig. 12, *vd.*). These, in the absence of distinct testes, will serve to identify the sex as certainly as the presence of an oviduct in the female.

Unless the sexual organs can be recognised without any doubt, it is better not to mark the sex on the label. If, however, it has been certainly determined, write it down at once. ♂ is the sign for male, and ♀ for female.

III.—Directions for Collecting Eggs.

No egg should ever be taken till the species has been fully determined, either by careful observation of the parent birds with a good

pair of glasses or, if absolutely necessary, by shooting one of them. If the birds are not seen and positively identified, it is mere useless cruelty to take eggs, as in most cases they cannot be named with certainty and are of no scientific interest. The eggs of some few species, such as the Great Auk, are of course unmistakable, but generally speaking, in ninety-nine cases out of a hundred, unidentified eggs are best destroyed.

Eggs should always be collected in clutches—that is to say, the whole number of eggs in the nest should be taken, and they should therefore be left undisturbed, if possible, till the full complement has been laid. With Ducks' eggs it is most important that samples of the down forming the lining of the nest should be carefully collected, together with all feathers found in the nest. These should be placed in a small box or envelope, named, and dated. In blowing eggs, the plainest side should be selected, and a single hole bored in the middle of the shell with a drill specially made for that purpose. After the hole has been drilled, the lining membrane covering the aperture should be removed, in large eggs with a fine-pointed knife, in small eggs with the point of a toothpick. When the skin covering the hole has been removed, the egg can be blown much more easily, and when washed out it will drain much better.

The egg should be held hole downwards over a lump of cotton or soft flannel, and the point of the blowpipe, also specially made for the purpose, placed in juxtaposition to the hole. By blowing gently or strongly, in proportion to the size of the egg, the contents of the shell can then be readily driven out. Having emptied the shell entirely of white and yolk, and rinsed it out once or twice with water, it should be washed out with a weak solution of carbolic acid, and placed on fine sawdust, or, if that is not available, on blotting-paper, hole downwards, to drain.

When eggs are too hard set to admit of their being blown in the ordinary way, other means of extracting the chick must be resorted to. With large eggs in which incubation is not very far advanced, a farly large hole should be drilled, and as much as possible of the contents of the shell removed by blowing. The remainder of the chick can be got out with the help of a hook, scissors, blowpipe, and plenty of water; but the operation takes time. In cases of

emergency, and when time is of importance, a neat oval piece of shell can be cut out with a sharp pair of curved dissecting scissors; the chick can then be cut up in the shell and extracted without trouble. When the shell has been thoroughly cleaned inside, the oval piece can be neatly replaced and fixed with collodion or fine glue.

If it is very important not to damage the shell, other and more tedious means have to be resorted to. A fairly large hole is bored, and when as much of the contents of the egg as possible have been blown out—that is, all yolk and albumen—a drop or two of saturated solution of Caustic Potash should be introduced with the aid of a glass suction-pipe. It is *most important* that all yolk and albumen be removed before using the solution, as the Potash turns the former into an indiarubber-like mass which cannot afterwards be removed, and the latter into a hard glass-like substance. The solution should be left in the egg for about twenty minutes, and when washed out, a portion of the embryo will come with it in a softened state. This operation may have to be repeated several times. The Potash should not be left in the egg longer than is absolutely necessary, or it will destroy the shell. Caustic Potash should be used with great care, and kept carefully from the fingers and mouth, and the bottle in which it is kept should be very strong and securely stoppered. With very delicate eggs in an incubated condition, it is sometimes safest to fill the shell with water and let the chick gradually rot; but this is a slow and disagreeable process, and not always possible to carry out when one is collecting in the field. The delicate inner lining of the egg-shell enveloping the embryo, known as the Allantois, must be removed, or the shell will decay. This can usually be done by sucking up water into the mouth and blowing it into the shell through the blowpipe; but if the membrane cannot be extracted in this way, a piece of string or cotton according to the size of the egg should be inserted and twisted about. The lining membrane usually sticks to the cotton and can then be withdrawn.

When neither drill nor blowpipe is available, eggs can easily be blown through two holes, bored one near each end by some sharp instrument such as a pin or sharp thorn, the latter being often quite a useful substitute for a drill.

Egg-drills and blowpipes of various sizes can be obtained at almost any naturalist's shop.

When the egg is blown and dry, the name of the species, locality where taken, and date of taking should be written on the shell above and below the hole, also the number of eggs in the clutch should be indicated, and each clutch distinguished by a letter (fig. 14). If the eggs are too small and delicate to be written on with safety, they should be numbered, and full data written on a paper packed with them and bearing a corresponding number. The name, or at least the initials, of the collector should also be added.

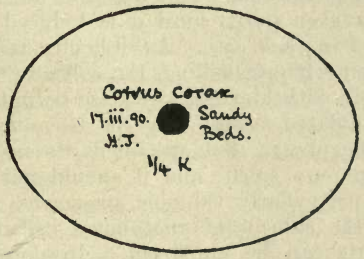

FIG. 14.—Showing the method of labelling an egg. ¼ k indicates that the egg is one of a clutch of four distinguished by the letter k.

Reptiles, Batrachians and Fishes.

I.—Collecting Outfit.

Spirit.—The collector should provide himself with the best and strongest alcohol procurable. This can afterwards be diluted with water or with weaker spirit, until it is reduced to the degree of strength required in each case. As difficulty is often experienced in obtaining spirit while travelling, the collector is advised to take a sufficient supply with him. If an excise permit can be obtained, "industrial methylated spirit" may be recommended on account of its greater cheapness; but specimens do not keep so well in this liquid as in pure spirit, and it should not be used for the preservation of particularly valuable specimens, or of such as are likely to form the subject of anatomical investigation, in cases where pure spirit can be employed. In default of spirit the collector may use arrack, brandy, rum, or any other spirituous liquid which he can procure, provided it possesses the requisite strength. Any spirit which takes fire immediately on the application of a light, without having been previously warmed, is strong enough to be used for the preservation of animals.

Specimens kept in very strong spirit become so hard and rigid that they cannot be examined without difficulty. In order to avoid unsatisfactory preservation of this nature, some dilution of the spirit is usually advisable. The strength of the bought spirit should first be ascertained by means of an alcoholometer * graduated in percentages of alcohol; and, with the assistance of a glass vessel graduated in cubic centimetres, the strength of the spirit can then

* For more detailed information about spirit and the method of testing its strength, *see* No. 13, "Alcohol and Alcoholometers," p. 208.

be reduced with sufficient accuracy to any desired extent by means of the following simple rule :—

Take the number of cubic centimetres of the strong alcohol which is identical with the desired percentage, and add enough water to make the number of cubic centimetres of the mixture identical with the percentage of the strong alcohol. To illustrate this rule :—

To make 50 per cent. alcohol from 95 per cent. alcohol, add to 50 cc. of 95 per cent. alcohol enough water to make 95 cc. of the mixture.

To make 40 per cent. alcohol from 70 per cent. alcohol, add to 40 cc. of 70 per cent. alcohol enough water to make 70 cc. of the mixture.

Larger or smaller quantities than those indicated in the illustrations can be made by using different units of measurement, or by multiplying or dividing those quantities by a suitable number.

Spirit in which specimens are finally packed for transmission should contain 74–80 per cent. by volume of alcohol, or be about 30–40° over Proof.

It is sometimes found advisable to mix an emetic, crushed colocynths or other disagreeable ingredient with the spirit, in order to deter pilferers from drinking it.

A collector who resides in a locality for some time would find a small still extremely useful, with which to redistill his supply of weak or foul spirit, or the bad liquor sold to him as rum, and thus bring it to the proper strength. It is advisable to be sure that the laws of the country in which the collection is being made do not forbid the use of a still.

Chloroform.—This substance is useful for killing Reptiles and Batrachians.

Formalin.—The use of formalin as a preservative is not recommended for Reptiles, Batrachians, or Fishes. Batrachians and Fishes, which have a soft and delicate skin, are in particular injuriously affected by this substance.

Cases and Vessels.—The most useful are four-sided zinc boxes measuring 12 by 6 inches and 18 inches high. On the upper surface they should have a round opening 4 inches in diameter,

closed with a screw cover; to fit tightly, a ring of rubber or leather is fastened round its margin. Each of these zinc boxes should be placed in a closely fitting wooden case, with a lid secured by hinges and a bolt, and furnished on two opposite sides with handles of leather or rope.

The traveller will require from two to four of these cases, using them for the reception, and first immersion in spirit, of specimens obtained from day to day. The specimens should be kept in them for some time, and repeatedly examined until the case is full, or the specimens are ready to be packed. The spirit, which gets weaker with every specimen immersed in it, has to be renewed occasionally. These cases are very convenient and practical; but they can be replaced by simpler arrangements, such as common earthenware jars closed with cork or rubber. The conditions which any such vessels ought to fulfill are: (1) that they are spacious; (2) that they have a wide opening; and (3) that they can be closed tightly so that the spirit cannot evaporate, but yet that they can easily be opened at any moment.

Specimens which are to remain permanently packed or to be sent home should be placed in zinc cases, of varying sizes, with closely fitting wooden outer covers. But these cases must not be made too large, because the specimens suffer if the pressure of the contents becomes too great, and because the risk of damage to the cases themselves increases in proportion to their size. Such a case ought not to have a greater internal capacity than 18 cubic feet at the utmost; and when the specimens require the length of the case to be increased, the depth or breadth must be reduced in proportion. The traveller may take a certain number of cases ready made with him, packing them with articles needful for the journey; or, to save space, he may take only zinc plates cut to the proper size, and put them together when required: the wooden outside boxes may be obtained almost anywhere. But under all circumstances he must provide himself with a soldering-apparatus, after having learnt its use. A pair of shears for cutting the zinc is also useful.

Wooden casks are unsuitable, especially in hot countries, for the transport of specimens in spirit. They should not be employed

except in cases of necessity, or for packing large or salted specimens.

Very small specimens, or those which are specially liable to be damaged, must not be packed with larger ones, but must be kept separately in small bottles, jars or tubes. In closing these, bees' wax may be used with advantage, or a mixture of bees' wax and vaseline; sealing-wax should never be used, as spirit readily dissolves it.

Labels.—It is essential to label all specimens fully. Particular care should be taken to record the locality and the date of capture, and to write as distinctly as possible. The labels may be written with a soft lead pencil on unsized paper, and placed in the spirit. Parchment labels are stronger than those made of paper, and if used should be written on with Indian ink. Ordinary ink, which washes out in spirit, is unsuitable for labelling. Certain kinds of Indian ink are, however, to be recommended if allowed to dry thoroughly before being placed in the spirit; but they should not be used unless they have been found by trial to be satisfactory. If the specimens are wrapped up separately the label should be placed inside the wrapper with the specimen. In the case of those which are not protected by a wrapping of linen or some other material, care should be taken to arrange the labels in such a way that they are not liable to be torn off by the projecting parts of other specimens.

In preparing fishes a second label may be placed under the left gill-cover, as a precaution in case the other label should be detached and lost.

Note-books.—It is advisable to keep a journal in which to enter particulars, such as coloration during life, circumstances of capture or native name, for which room cannot be found on the labels. Care should be taken to make it clear which specimen in the collection is thus referred to. This can easily be accomplished by giving each specimen a number following the date (*e.g.*, March 9, 1922, 3) and entering the same numbers in the journal.

II.—Reptiles and Batrachians.

A.—Reptiles.

1. Preservation of Specimens of Small or Medium Size.

Reptiles should be preserved in spirit whenever practicable. All reptiles—except large Turtles, Crocodiles and Alligators above 4 feet long, and Snakes above 10 feet long—are suitable for preserving in spirit. A deep incision should be made in the region of the stomach, and a second at some distance before the vent; a portion of the contents of the stomach and intestine, which might conduce to putrefaction, being emptied out, and the spirit being allowed free access to all internal parts. It is most important that each specimen should be properly labelled at this stage, before its history has been forgotten. The specimens are then placed in one of the preparatory vessels or boxes described above. In a few days (or in hot climates after not more than one or two days) the specimens must be removed to a second vessel containing stronger spirit, and must remain there from eight to fourteen days. If they then appear to be sound and well preserved, they may be left in the same spirit till the time comes for finally packing them; but if they are soft and flabby, and discharge mucous matter discoloured with blood, they must be placed for a longer or shorter time in fresh spirit at least 20° over Proof (about 69 per cent. by volume of alcohol). *Specimens which show distinct signs of putrefaction must be thrown away*, as they endanger the whole contents of the box. Similarly, specimens which are already decomposing when obtained must not be taken for preserving unless disinfected by a solution of chloride of lime (a tablespoonful of the solution in one pint of water) or other disinfectant poured into the mouth and injected into the abdominal cavity.

The spirit which is used in this preliminary process of course becomes weaker and weaker. So long as it is 15° under Proof or 10° in hot climates (about 45–50 per cent. alcohol) it can be used for the first stage of preservation. If it sinks below this strength, it is of no further use to a collector who has not the means of

redistilling, unless he filters it through powdered charcoal, and then brings it up again to the needed strength by the addition of strong alcohol. Sediments on the bottom of the vessel, or contaminated and badly smelling spirit, are better thrown away.

As soon as the collector has accumulated a sufficient quantity of well preserved and well labelled specimens, they should be sent home at the earliest opportunity. For transport they must be packed separately in clean white linen, muslin or paper, and packed as tightly as possible. No empty space should be left in the cases above or at the sides, so that the contents may receive no injury from the shaking unavoidable during transit. When the case is full, the cover is soldered down, after a hole of about half an inch in diameter has been made in it. The case is then filled through the hole with spirit 30–40° over Proof (74-80 per cent. alcohol), and care must be taken that all the air is driven out by the liquid; when this is ascertained to have taken place, a small square piece of zinc is soldered over the hole. In order to make quite sure that the case is securely closed, it is turned upside down, and left thus for the night, in order to discover whether any leakage exists.

2. Preservation of the Dry Skin or Skeleton of very Large Reptiles.

1. *Tortoises and Turtles.*—It is no easy matter to kill a large Tortoise or Turtle which is to be prepared for a collection, even if chloroform is used. The traveller will perhaps consider whether it may not be possible to bring the animal to Europe alive, as it can live for ten or twelve months without food in some corner of the ship. If this is impracticable, a long knife should be thrust into the base of the neck in the direction of the heart, in order to sever some of the large blood vessels. Both the skeleton and the skin of the same individual may be preserved; but if one or the other has to be sacrificed, it is of more importance to preserve the skeleton. First the abdominal shield or plastron * must be removed by sawing through the narrow isthmus on each side, and then

* The "plastron" is the part of the shell which belongs to the ventral or lower surface of a Tortoise or Turtle.

carefully separating with a knife the skin which is attached to the bone in front and behind. A straight cut is then made along the middle, from the chin backwards; and after the skin has been turned aside to the right and left, it is easy to remove all the soft parts, as well as most of the muscles of the neck, and the limbs, shoulder-blades and pelvis. The head is the only part which is troublesome, as, in removing the soft parts, its skin and bones may easily be injured. If the skin is to be preserved, as well as the carapace * and the bones, the whole of the inner surface must be painted with arsenical soap. Finally, all the parts are bent back into the hollow of the carapace, and allowed to dry there. When they are dry, the plastron is fixed in its natural position by tying a string round the carapace. This method may also be used for small Tortoises, if the traveller has to be economical with his spirit, and thus cannot preserve them entire.

2. *Crocodiles and Lizards.*—In the case of large Crocodiles and Alligators, it is impossible to preserve both the skin and the skeleton of the same individual. To prepare the skin, it must be cut through along the middle of the underside, from the chin to the end of the tail. Care must be taken not to damage the skull, so that this part at least may be saved, in case the skin should happen to be spoiled. The inside of the skin must have every particle of subcutaneous fat scraped away, and should then be brushed over several times with a strong solution of alum, to which a few grains of corrosive sublimate have been added.

It is strange that perfect specimens of large Crocodiles and Alligators are somewhat uncommon in collections. The Gharials of India and of the Malay Peninsula and the larger islands of the Eastern Archipelago (Sumatra or Borneo), and also the narrow-snouted Crocodile of North Australia, are particularly valuable to palæontologists and zoologists. The collector should endeavour to procure skulls and skeletons of these reptiles of different ages. In preparing such a specimen for a skeleton, the bulk of the flesh

* The "carapace" is the curved upper part of the shell which covers the body.

is cut off the bones, and the bones themselves are left in their natural connections. It is particularly important to allow the hands and feet to dry up with all the bones in place. The body is then divided into several portions of a convenient size for packing, care being taken to cut between two vertebræ of the "backbone" and to avoid injury to other bones. These reptiles possess "abdominal ribs," which are unconnected with the rest of the skeleton and lie in the muscles of the abdomen. In order to preserve them in their entirety, the skin of the abdomen, with the muscular layer attached to it, is cut away *in toto* and dried, to be macerated at home.

In the case of the South American Alligators the collector should endeavour to preserve the external dorsal and ventral plates of each specimen in their natural position in the skin, as it is otherwise difficult to determine the species correctly.

3. *Snakes.*—Specimens of a greater length than 10 feet cannot well be preserved in spirit; and Pythons and Boas, which have a comparatively large girth, are unsuitable for this mode of preservation if they approach the size mentioned. They must therefore be skinned, but not in the manner frequently adopted, by making a short cut behind the head and then skinning the animal like an eel, as the scales are too much injured by this treatment. The animal should be split up along the whole median line of the belly and tail with a pair of strong scissors, and the skin should be removed with a knife from the line of the cut towards the back. A skin thus prepared does not occupy much space, and, if circumstances permit, is better preserved in spirit than dry. Of course the head then requires no further preparation.

It must be borne in mind that large or handsomely-coloured snakes belong mostly to very well known species, and are not worth while collecting except in out-of-the-way or unexplored districts.

Large Pythons and Boas are so frequently brought to Europe alive that most museums have opportunities of obtaining good skins and skeletons; and therefore it is not worth while for a traveller to preserve them, unless they are of a size to verify

reports in which Pythons exceeding 25 feet and Anacondas of over 30 feet are mentioned.

3. Other Notes on Collecting Reptiles.

The determination of the large River-turtles (*Trionyx*) which inhabit the fresh waters of Asia and Africa is a matter of considerable difficulty and uncertainty, which cannot be dispelled except by collecting afresh large numbers of all the species without exception. The traveller should try to obtain as many specimens as possible of all ages, with their exact localities, and always with the skulls. It would also be particularly interesting to receive specimens taken *in copulâ*.

Collecting Sea-turtles seems unlikely to lead to important results. Very large specimens of the Leathery Turtle (*Dermochelys*), and more especially its skeleton, are, however, much sought for by museums. It would also be important to obtain embryos in the egg in different stages of development, * as well as young specimens, which do not require much spirit.

Comparatively little is known at present of the habits and mode of reproduction of *Lizards;* and when the traveller has an opportunity of observing any of these animals for some time, he should note down everything which appears to him remarkable.

Of *Snakes* it is urgently recommended that the small and obscurely-coloured species should be searched for. Many of these live habitually underground, or are nocturnal animals which can only be obtained by digging up the soil or by searching for them under stones or among decaying substances. The *Sea-snakes* are very numerous in species and varieties, and should receive special attention. It should be remembered when handling them that these animals belong to a specially poisonous group of snakes. The collector should obtain all the specimens he can (except the species common in harbours); but he must be careful to note the

* Embryos of all species which are enclosed in egg-shells should be preserved in the strongest spirit, after several holes have been pierced in the shell, in order to empty it of the fluid portion of its contents.

exact locality (latitude and longitude) where each specimen was obtained. Some of the Sea-snakes found to the north of Australia reach a considerable size, and it is desirable that the traveller should preserve even the largest in spirit. Such specimens require to be immersed for a comparatively long time in strong spirit, which should be changed several times.

Many snakes adorned with very bright and variegated colours during life lose them after death. If the traveller is a draughtsman, and can spare time, he should make a sketch of the Snake, and indicate the colours which it presented during life, so that a complete drawing of the species can afterwards be made, if necessary, with the assistance of the sketch.

B.—Batrachians.

The majority of Frogs, Toads, Newts, Salamanders and Cæcilians, and their larvæ, are covered with a very soft skin; they should be placed in weaker spirit than reptiles, in order to prevent the shrinkage of those parts which are particularly soft. Although 50 per cent. spirit may be used for the first few days, it is necessary to examine the specimens every day, as the intestinal canal frequently contains much food and water. The spirit must be changed three times at least, and often still more frequently, and finally replaced by spirit of about 69 per cent. (20° over Proof).

There are many remarkable facts connected with the reproduction and sexual relations in this class of animals. If the traveller has an opportunity of observing examples of one or more species during the breeding season, he should, if possible, obtain eggs, watch their development, and collect larvæ in different stages of growth. Larvæ correctly determined as to species are most valuable for the study of these animals, while those of whose origin nothing is known are almost always worthless.

Special interest attaches to the breeding habits of Batrachians, many tropical frogs and toads ovipositing on the ground or on bushes or trees, and carrying their eggs or young, or protecting them in nests made of leaves held together by a frothy secretion.

As this subject has been much neglected by collectors, every effort should be made, especially by those able to go about after dark with a lantern (these Batrachians being mostly nocturnal), to add to our knowledge by procuring such specimens with their eggs or young, and taking full notes on the breeding operations, with sketches of the position of the pair *in amplexu*, of the appearance of the nest (often overhanging water), etc.

Cæcilians, limbless Batrachians suggestive of large earthworms, deserve special attention from the point of view of their habits and mode of development (oviparous or viviparous) on which very little is known. These creatures are rare in collections, and all specimens are worth preserving.

Special desiderata :

The large, short-snouted crocodile (*Crocodilus robustus*) of Central Madagascar.
The large river-turtles of New Guinea (Fly River and others).
The long-tailed snapping-turtle of New Guinea.
The turtle (*Trionyx*) of Lake Galilee.
The small, handsomely-marked land tortoises of South Africa.
The gigantic lizard, *Varanus komodensis*, said to reach 30 feet, of Komodo Island, between Sumbawa and Flores.
The two Boid snakes (and other reptiles) of Round Island, near Mauritius.
The giant lizard (*Lacerta simonyi*) of the Roques de Zalmor, near Hierro, Canary Islands.
The small viviparous toads of East Africa.
The giant frog (*Rana goliath*) of Cameroon.

Special localities for Reptiles wanted : Greece and the Archipelago, Turkey in Europe, Canary Islands, Cuba, Kilimanjaro, Interior of China, Southern Yunnan, Lower California, Eastern slope of the Andes of Ecuador.

III.—Fishes.

1. Preservation and Collection of Fishes.

Preservation in Spirit.—The preservation of fishes in spirit is very similar to that of reptiles and batrachians. The same kinds of spirit and cases may be used ; but it is advisable to keep fishes, batrachians and reptiles separate, at least during the preliminary stages of preservation. It must be remembered that fishes contain more water than reptiles, and consequently that the spirit employed becomes diluted much more rapidly and requires to be changed more frequently. In the case of comparatively large (2 feet long) and fleshy fishes, the spirit penetrates very slowly into the interior ; and even though the specimens appear to be in the best condition externally, the inner layers of muscle above and around the vertebral column may be decomposing. It is therefore necessary to make several deep incisions in the muscular part of the back and tail, in addition to those made along the abdomen. In making these incisions care should be taken to avoid injuring the scales more than is necessary. Fishes which are loaded with fat in the muscles, liver, or abdominal cavity, should be placed by themselves in very strong spirit until the greater portion of the fat is extracted ; to accelerate this process, the liver should be deeply incised and the masses of fat in the abdominal cavity should be removed. Before being placed in spirit, the fish should be washed in water to remove the slime, although the delicate skin which covers the scales should not be rubbed off.

In collecting fishes care should be taken to preserve the scales intact ; those which lose them easily, like the *Clupeidæ* or Herrings, should be wrapped in pieces of paper or linen before they are placed in spirit.

It occasionally happens in hot climates that, from some cause, the collector cannot succeed in preserving his specimens from decomposition even with the strongest spirit. In such cases it is advisable to add some arsenic, corrosive sublimate * or other

* This substance has a strong corrosive action on certain metals ; and spirit containing it should be put into glass or earthenware vessels.

disinfectant to the spirit; but the traveller should inform his correspondents that he has adopted this mode of preserving.

Drawings.—If the colour is remarkable, the traveller is recommended to make a coloured sketch of the fish before preserving it. It is generally important that coloured drawings made from life should accompany a collection. If the actual original specimens have not been preserved in the collection the drawings have only a subordinate value.

Skins.—Dried skins of fishes are, as a rule, unsatisfactory for scientific study, and their collection is not recommended.

2. Deep Sea and Pelagic Fishes.

Marine fishes include two specially interesting groups of species:—(i.) those which are adapted to living at great depths and never come to the surface (deep-sea fishes), and (ii.) those which live at or near the surface of the open sea and only rarely approach the coasts (pelagic fishes).

Deep-sea Fishes.—These can only be collected systematically with the aid of a ship specially fitted out for this sort of work. Collectors who are restricted to their own limited resources can hardly do more than dredge or trawl in depths not exceeding 100 to 200 fathoms. Two other modes of collecting deep-sea fishes may, however, be recommended. One of them is in actual use on the Portuguese coast and in Madeira by fishermen, who employ a strong line (long-line, spiller, trot), sometimes as much as 800 fathoms long, with a weight at one end, and supporting-hooks of various sizes on thinner soft lines (snoods), fastened to the main line at regular distances of 1 or 2 fathoms; in fact, a long line such as is used in cod-fishing. The second method is to sink baskets constructed of withes or galvanized zinc, like lobster-pots,* and to examine them after twelve or twenty-four hours.

The majority of deep-sea fishes are so fragile that their preservation requires special care; they should be wrapped in linen,

* These baskets are dome-shaped with flat bottoms, about 2 to 3 feet across, and with an opening 6 inches in diameter sloping inwards from the top. The bait is fixed opposite the opening and somewhat on one side of it.

and kept singly, or only a few specimens together, in a separate jar. A long cut should be made in the abdominal cavity, and strong spirits of wine, from 20° to 30° above Proof (70–75 per cent. alcohol), should be used to ensure the preservation of the internal organs.

Pelagic Fishes.—No opportunity should be lost to obtain pelagic forms, especially the young larval stages of development which occur at the surface. They can be obtained by means of a small narrow-meshed net (" tow-net ") dragged behind a boat. The sac of the net should be at least 3 feet deep, and should be fastened to a strong brass ring 2 or 2½ feet in diameter. The net is suspended by three lines passing into the strong main line. It can only be used when the vessel moves very slowly, the speed not exceeding 3 knots an hour, or when a current passes the ship whilst at anchor. By using suitable weights two or three of these tow-nets can be used simultaneously at different depths. This kind of fishing should be tried at night as well as in the daytime, and at different depths below the surface, as many fishes come to the surface only after sunset, while others normally inhabit layers of water at some distance below the surface. The net must not be left long in the water (from five to twenty minutes only), as delicate objects are liable to injury by the force of the water passing through the meshes.

The latitude and longitude should be carefully noted in the case of all specimens obtained in the open sea.

3. Other Notes on Collecting Fishes.

By the examination of the contents of the stomachs of large fishes (Tunnies, etc.) or Dolphins caught in the open sea, rare forms may be discovered. Objects found floating in the open sea, such as pieces of wood, baskets, larger or smaller masses of weed, etc., deserve the collector's attention, as small fishes and marine creatures of all kinds generally swarm round them. Shallow banks situated at a considerable distance from land are likely to yield a valuable store of fishes of all kinds, which may be obtained either with hook and line or with the above-described fish-baskets.

Fresh-water Sharks, such as those of Nicaragua and the Zambesi, are worth collecting.

It is important to obtain information relating to fishes which either are actually used as food (fresh or for exportation) or may become an important article of trade. The following fishes, therefore, deserve special attention: Sturgeons, the species of *Gadus* (Cod, Whiting, Haddock, etc.), *Thyrsites*, the *Chilodactylus* of the Southern Seas, the Tunnies and Sword-fishes of the Indo-Pacific, Salmonids, Clupeids (Herring, Sardine, etc.), and others.

On the other hand it is well known that the flesh of various sea-fishes possesses poisonous properties either constantly or at certain seasons or in certain localities. Observations should be made on the causes of these properties, on the nature of the poison, and on its operation on other animals.

Other fishes, the flesh of which is quite harmless or even well flavoured, are armed with special poison-organs. It would be very desirable to investigate this poison in fresh fishes, and to experiment with it as to its effect on other fishes.

All observations relative to sex and propagation are of interest; observations on secondary sexual differences, hermaphroditism (whether normal or abnormal), the numerical relation of the sexes (whether monogamous or polygamous), spawning, and migrations; nest-building, care for the young, etc. The ova of pelagic fishes, many with peculiar appendages on the outer membrane, are frequently met with floating in the open sea, sometimes singly and sometimes in clusters. Every opportunity of observing their development, and of tracing the stages of growth of the young fishes, should be taken advantage of.

As long as a species of fish is allowed to exist in a district without molestation, it attains a much greater size than subsequently, when it is diligently sought after, and when none of the individuals are allowed to reach their full growth. For this reason alone it is desirable to collect the largest individuals; but if the traveller is unable to preserve them, he should at least record their length and weight.

In hot countries, where the streams and ponds are liable to dry up, many fishes are compelled to breathe air temporarily, to travel

considerable distances overland, or to fall into a state of torpidity. Observations on such habits which are verified by the traveller himself are of incomparably greater value than what he learns by hearsay from the natives. It would also be interesting to know whether the fishes of the Arctic and Antarctic zones are able to maintain life when enclosed in ice, and, if so, for how long.

The skin of many pelagic fishes is provided with smooth white or pearly organs, which are small and round on the body of the fish, but larger and of various shapes on the head, especially near the eyes, where they are sometimes of a pinkish or greenish colour. These are the so-called phosphorescent organs; and although their luminous properties are now generally admitted, it is desirable to obtain corroborative evidence as to their function from the living fishes, with special reference to the question whether the luminosity is subject to the will of the fish.

Insects in General.

In the following instructions the orders of insects are generally referred to by their scientific names ; *viz.*—

Orthoptera. Earwigs, Cockroaches, Mantids, Phasmas (Stick-insects), Crickets, Locusts, Grasshoppers.

Hemiptera. Bugs, Cicadas, Lantern-flies, Froth-flies, Aphides, Scale-insects.

Neuroptera. Termites (White Ants), Stone-flies, Ant-lions, Lace-wings, May-flies, Dragon-flies.

Trichoptera. Caddis-flies.

Lepidoptera. Butterflies and Moths.

Coleoptera. Beetles.

Hymenoptera. Saw-flies, Gall-flies, Ichneumons, Ants, Wasps, Bees.

Diptera. Midges, Gnats or Mosquitoes, Daddy-long-legs, Horse-flies, House-flies, Tsetse-flies, and other two-winged flies.

Collecting Material and Apparatus.

(These can be obtained from Messrs. Watkins & Doncaster, 36, Strand, London, W.C.2, or other natural history dealers.)

Nets, pill-boxes, glass tubes, cyanide killing-bottle, collecting tin, zinc collecting-box, collecting-bottle, strong knife or digger.

Pins, needles mounted in handles, cork-lined boxes, cork-carpet or pith, setting boards, forceps (curved and fine), gun-wad punches, brushes, gum, card, pocket-lens, fine-pointed scissors.

Naphthaline in flakes, creosote, carbolic acid, chloroform, spirit, perchloride of mercury (corrosive sublimate).

Nets of at least two kinds are necessary for general collecting : a stout net for beating, sweeping, etc., and a lighter one for catching insects on the wing. For capturing tropical butterflies, a large

"kite-net" is essential; the brass Y, of three pieces *soldered* together, usually supplied with these is not strong enough. Those with *brazed* joints are better, but those made in one piece are greatly to be preferred. For net-bags fine mosquito netting should be used and not the cheaper "leno"; one or two spare net-bags should be kept in readiness in case the one in use gets torn.

Pill-boxes of all sorts are useful, and common chip-boxes are very handy; but it is specially desirable to have as many glass-bottomed boxes as practicable (assorted sizes, up to $2\frac{1}{4}$ inches in diameter, packed in nests one inside another). To prevent these getting damp, they should have at least the top and edges painted with enamel paint, or with shellac dissolved in absolute alcohol.

Glass tubes.—Glass tubes of various sizes provided with corks are very useful, especially for preserving minute insects, larvæ, etc., in spirit. The most convenient sizes are $1\frac{1}{2}$ inches by $\frac{3}{8}$ inch and 3 inches by 1 inch. The larger sizes make excellent killing-bottles for cyanide or chloroform.

Cyanide Killing-bottle.—One or two *Cyanide Killing-bottles*, not too large to be carried in the pocket when required; and a larger sized killing-jar, or materials for making one, as follows: $\frac{1}{4}$ lb. of cyanide of potassium,* 1 lb. of plaster of Paris, a glass jar with wide mouth and close fitting lid. Bottles suitable for charging with cyanide are supplied by Messrs. Watkins & Doncaster, and chemists will sometimes prepare killing-bottles to order, for customers who are well known to them. A cyanide killing-bottle or killing-jar should be prepared as follows: Take any fairly large glass jar (such as a pickle-bottle) with a wide mouth and closely fitting lid (a lever-lid such as those often

FIG. 15.—CYANIDE KILLING-BOTTLE.

* If it is intended to take cyanide to a damp tropical climate, it should be conveyed in the form of *lumps*, in a bottle with a tightly fitting glass stopper. Cyanide of potassium, which is a highly poisonous substance, is also sold in rods, and, in this form, might conveniently be carried in short lengths in hermetically sealed tubes of thin glass, of diameter and length just sufficient to take the section of cyanide rod.

fitted to pickle-bottles would answer admirably), and cover the bottom with a layer of dry plaster of Paris to the depth of ½ inch; pour in above this a layer equal in depth consisting of *powdered* cyanide of potassium, mixed with rather more than its bulk of dry plaster of Paris; cover this mixture with a layer of dry plaster of Paris to the depth of ¼ inch or so; and pour in above the whole a layer, ½ inch in depth, consisting of plaster of Paris mixed with water to the consistency of cream. As soon as the top layer of plaster is dry the jar is ready for use; the plaster, however, should be covered with several thicknesses of blotting-paper, to avoid risk of injury to specimens in case the surface should at any time become wet. To obviate the danger of cracking the jar, owing to the heat evolved when plaster of Paris is mixed with water, it may be advisable to stand the jar in warm water before adding the final layer. The exact amount of cyanide of potassium to be used is of no great consequence; but in the case of a properly prepared jar the odour should readily be perceptible on removing the lid; if it is not, the reason may be that the mixture is too dry, when a little water poured on to the top layer will probably set matters right. In preparing a cyanide killing-bottle for use in the tropics it is especially necessary to use only the minimum quantity of water. After some months' use the cyanide loses its efficacy (to obviate this so far as possible the jar should never be allowed to remain open), and the mixture must then be renewed. Though expensive, rubber corks are much the best for cyanide bottles.

A rough and ready method of making a killing-jar or bottle is to cover the bottom with a layer of powdered cyanide, and to place above this a number of layers of blotting-paper. The layers of blotting-paper immediately in contact with the cyanide must be slightly damped, but only sufficient water should be used to cause the cyanide to give off its odour. The top layer of blotting-paper must on no account be wet, and the less water used the better.

Another method is to place in the bottom a wad of cotton-wool moistened with chloroform.

Collecting-tin.—This is very useful for some purposes. It has a false bottom of perforated zinc, and in the space at the bottom is placed some blotting-paper, moistened with a few drops of

chloroform or pure benzole. The insects are confined in the upper part, and to prevent them from rolling about, it is well to put in first some crumpled pieces of blotting-paper or muslin.

Zinc Collecting-box.—Boxes made of zinc and lined with cork are to be had from natural history agents. The cork should be well moistened with water, and then sprinkled with four or five drops of strong carbolic acid. Specimens can be kept in a relaxed state for a considerable time in a properly prepared box.

Collecting-bottle.—This is a bottle specially made for entomologists, and is very useful for collecting small Coleoptera, etc. It is flattened from side to side, so that it may be carried conveniently in the pocket, and the cork is pierced by a glass tube or large quill,

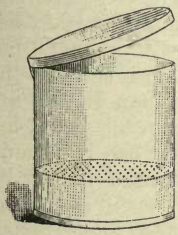

FIG. 16.—COLLECTING-TIN.

FIG. 17.—COLLECTING-BOTTLE.

FIG. 18.—DIGGER.

fitted with a plug. A piece of crumpled muslin should be placed in the bottle for the insects to cling to. The cork should be covered with sealing-wax on the inside to prevent insects burrowing into it.

Trowel and Digger.—One or both of these are necessary for digging in the ground, ripping bark off trees, etc. A narrow fern-trowel answers best.

Pins.—The ordinary entomological pins (manufactured by Messrs. D. F. Tayler & Co., New Hall Works, Birmingham, but also obtainable from dealers in entomological apparatus) in use in the Museum are Nos. 11, 16, 7, 10 and 20. No. 11 is a stout, long ($1\frac{1}{3}$ inch) pin for large specimens, No. 16 being slightly thinner and slightly longer; both of these numbers are sold at 1*s.* 3*d.* per

ounce. No. 7 (3*s.* 3*d.* per ounce) is a fine pin, rather less than 1 inch in length, suitable for large Diptera and similar specimens. No. 10, of the same thickness as No. 7 but shorter (just over $\frac{7}{12}$ inch in length), is sold at 4*s.* 6*d.* per ounce. No. 20 ($\frac{7}{12}$ inch in length, 9*s.* 6*d.* per ounce) is a very fine, short pin, suitable, if held with the forceps near the point, for pinning small, soft-bodied insects, including all Diptera but the largest. An ounce of No. 16 contains about 320 pins; an ounce of No. 20 about 3,750, but Nos. 7, 10, and 20 are obtainable to order from the makers in quarter-ounce boxes.

Needles mounted in handles.—Two or three of these will be found useful for arranging legs and wings.

Two or three cork-lined entomological store-boxes.—These can be obtained from Messrs. Watkins & Doncaster, or any other dealer in natural history apparatus. For a collecting trip or expedition of some duration, the boxes should not be smaller than about 18 inches by 12 inches, and they must be sufficiently deep to prevent the heads of the pins from coming into contact when both sides of the box are filled. Provided, however, no pins larger than No. 20 are used, and discs (*see* "Instructions for Collectors, No. 5," p. 88) are not employed, several hundred small-sized specimens can be accommodated in a "postal" store-box measuring about 7 inches by 3½ inches. When baggage is necessarily limited, such boxes are very convenient. Should the collector run out of store-boxes, *cigar-boxes*, in the bottom of which is fixed a layer of cork-carpet or pith, make efficient substitutes; but if pith be used, it should not be less than ½ inch thick.

Cork-carpet or pith.—Two or three sheets about 6 inches square, on which to perform the operations of pinning, etc. (cork-carpet can be obtained at Harrods' Stores, Brompton Road, London, S.W.1).

Setting boards (assorted sizes).—These are only *necessary* for those who wish to set Lepidoptera, Orthoptera, etc. It is not nowadays customary to set Diptera (*see* p. 89), although it is often advantageous to do so.

Forceps.—Entomological forceps are made with curved points for taking hold of pins: straight, fine-pointed forceps for setting are also very necessary; they should have very little spring, and

are best made of brass. Forceps of both kinds are obtainable from G. Buck, 242, Tottenham Court Road, London, W.1.

Gun-wad punches, Nos. 4, 12, and 20 bores (from any gun-maker), for punching discs of card.

FIG. 19.—FORCEPS.

Gum.—For gumming small beetles, etc., on card some entomologists use gum-tragacanth, as it is not conspicuous; but it has the great disadvantage of being very difficult to wash off. Gum-arabic, with a very small quantity of powdered loaf-sugar and one or two drops of glycerine, is perhaps the best mixture. If pure gum-arabic is used, the insects are liable to spring off. The sugar and glycerine prevent this; but the latter must be used very sparingly, as it has a tendency to attract moisture, which is one of the entomologist's greatest foes. For some purposes, Le Page's liquid glue (Russia Cement Co.) is invaluable. Some entomologists use McCaw's seccotine, a very similar preparation, which has the advantage of being sold in metal tubes, so that it is portable.

Card.—A hard white card or 3-sheet Bristol board should be used for carding, as well as in the preparation of discs on which to mount Diptera; a supply of discs should be punched in readiness for use.

Pocket-lens.—A good "triplet" pocket-lens is perhaps the most useful for general purposes. For the examination of Diptera and other small insects, however, a *platyscopic* lens (Messrs. Charles Baker, 244, High Holborn, London, W.C.1; or John Browning, 63, Strand, London, W.C.2; price about 22*s.*) is needed. The magnifying-power should not be too high—from 6 to 8 diameters is about the best.

Alcohol, 90 per cent. (ordinary rectified spirit).

Perchloride of mercury (corrosive sublimate), aqueous solution, 1 in 500.

Creosote, naphthaline, chloroform; for protecting collections in the Tropics from mould and destructive insects.

Larva-preserving Apparatus.—This consists of spirit-lamp, small oven, and inflator. Instead of an oven a piece of copper gauze placed over the flame of the spirit-lamp answers very well. The whole apparatus can be obtained from entomological agents.

Collecting.

(Special notes on collecting *Diptera* will be found in "Instructions for Collectors, No. 5," pp. 79–97; the following paragraphs refer more especially to the other Orders.)

Besides those which may be caught on the wing with a butterfly-net, insects should be looked for on flowers, under bark of trees, in rotten wood, in decaying animal and vegetable matter, under stones, under fallen leaves (where there is moisture), at the roots of grass and trees, in ants' nests, in ponds and streams. When circumstances permit, and small insects are being sought for in dead leaves, etc., the leaves should be sifted over a sheet of paper. If the insects appear numerous, the siftings should be put into a holland bag, and examined at home. Many small insects which would be overlooked out of doors may be found in this way. Many insects are obtainable by sweeping herbage with a net; others by beating trees while a large net or umbrella is held underneath.

Ground-beetles may often be caught by putting a piece of meat or bone in a pickle-bottle, and burying it so that the mouth is just on a level with the ground.

Moths, some beetles, and other nocturnal insects are obtained by painting patches of "sugar" on the trunks of trees, and looking for them with a lantern after dark. The mixture used should be made with brown sugar, beer, and a little rum. Apples cut into quarters, smeared with sugar and hung up, also attract moths.

Moths may also be caught by hanging up a sheet with a lantern behind it. They are attracted by the light, and, settling on the sheet, may be picked off with glass-bottomed boxes or with the killing-bottle.

Some beetles and other insects may be obtained by hanging up skins of animals, or the carcasses of small mammals or birds. Strangely enough, some butterflies are attracted in this way, as well as by strong cheese.

Fleas, lice, and other parasites should be collected from the bodies of freshly killed mammals, birds, etc., from birds' nests, moles' nests, rabbit burrows and places of like nature. The name of the host should, if possible, be recorded on the label.

Killing.

Most insects can easily be killed by putting them into the cyanide-bottle ; but care must be taken to see that the sides of the bottle and the surface of the cyanide are not wet, as the more delicate insects are apt to stick to a moist surface and so become spoiled. To prevent this when collecting, the upper space may be partly filled with crumpled pieces of blotting-paper, among which the insects may bury themselves. This also prevents them from rolling about and injuring one another. Under no circumstances should the specimens be left in the cyanide a moment longer than necessary. Cyanide changes the colour of some insects, green becoming yellow, yellow turning to red.

Coleoptera, Hemiptera, Orthoptera, and other non-hairy insects may be killed by throwing them into boiling water ; but they must be taken out as quickly as possible, and placed on blotting-paper to allow the water to drain away.

Lepidoptera may be killed in the cyanide-bottle, and then pinned into the zinc collecting-box, where they can remain in a relaxed condition until it is convenient to set them.

Butterflies may be killed by pinching the thorax laterally while the wings are in an upright position ; but although this is necessary sometimes, it requires to be done with care, as it is apt to distort the body and render the specimens difficult to set.

Pinning and Preserving Insects other than Diptera.*

For small insects $\frac{1}{4}$ inch or less in length, which are not carded (*see* p. 71), preserved in spirit, or made into microscopical preparations, none but the finest pins should be used.

Generally speaking, in pinning any insect, the pin should be passed vertically through the middle of the thorax until only about $\frac{1}{4}$ inch remains above the specimen.

Coleoptera and some *Hemiptera*, *Orthoptera*, etc., should be pinned through the right wing-case near the base, and in such

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* For instructions as to the method of preserving and pinning *Diptera*, *see* pp. 87, 88.

a way that the pin comes out below and behind the middle pair of legs. As a rule, the pin should be equally distant from the base and the side of the wing-case.

FIG. 20.—HYMENOPTERA.

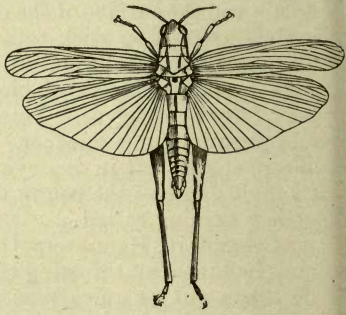

FIG. 21.—ORTHOPTERA.

Staging.—This is a very convenient method of dealing with small insects, for which a very fine pin is used. The insect is pinned in the usual way, the pin (a small one) is passed

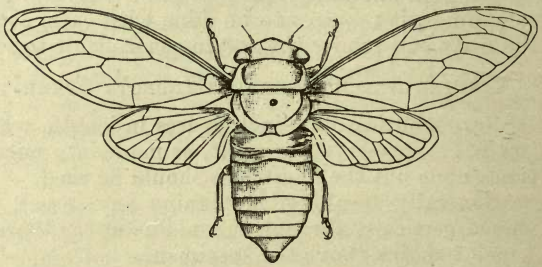

FIG. 22.—HEMIPTERA.

through one end of a narrow strip of card, cork, or pith, and a strong full-length pin through the other end of the strip. The strip may be vertical as in the illustration, or horizontal as in

carding. In this way the smaller insects can be kept at the same level as the larger ones, and there is plenty of room on the longer pin for labels. A very usual material for staging is a fungus called *Polyporus*, which is cut into strips and sold for the purpose by dealers. Sheets of celluloid (not too thin) which can be cut into small squares or oblongs as required are perhaps preferable to *Polyporus*.

Carding.—Small Coleoptera and certain Hemiptera are most easily mounted by being gummed on card. The card should only be sufficiently large to carry the specimen safely, with just room to take hold of the pin without risk of touching the insect. An

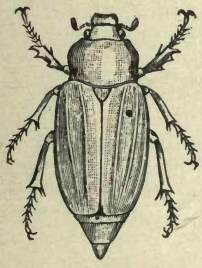

FIG. 23.—
COLEOPTERA.

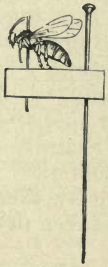

FIG. 24.—
STAGING.

FIG. 25.—
CARDING.

even better way is to place the insect *across* a very narrow strip of card. This, although not quite so safe, has the advantage of allowing some of the under side of the insect to be seen. The specimen should always be on the left hand of the pin when its head is turned from the operator.

Spirit.—Specimens preserved in spirit should be put into small corked glass tubes in a preservative fluid composed as follows: Alcohol (90 per cent.), 3 parts; distilled water, 2 parts; glycerine, 1 part. A plug of soft paper should be placed on the top of the specimens in each tube, to prevent injury from shaking or washing about, and there should also be inserted in the tube a slip of paper bearing the necessary data (locality and date of capture, and

collector's name) written in pencil. Specimens of different species or of different captures should, of course, be put up in separate tubes.

Habits of Insects.

Notes on the habits of insects, number of broods, whether common or otherwise, if taken singly or paired, are always of interest.

Nests, cocoons, and galls are of very small value, unless accompanied by the insect which constructs or causes them.

In collecting Termites, the kind of nest whence they were taken should be noted, or the nest should be photographed. Termites' nests with the occupants are much wanted. Specimens taken from one nest should be kept together, either in a tube or tied in a muslin bag. The same precaution should be taken with regard to the true ants (*Formicidæ*).

Specimens taken *in coitu*.—It is most important that specimens taken *in coitu* should be specially denoted, and that proper precautions be observed against possible confusion with other specimens. When possible they should be placed on the same pin, or in the same tube by themselves. In all cases a note to the effect that they were taken *in coitu* should be attached.

Labelling.

It is of the utmost importance that specimens should be labelled distinctly with the name of the locality in which they were taken, date of capture, elevation, etc. With regard to Lepidoptera, it is also important to mention whether they were obtained during the wet or dry season. These particulars should accompany the specimens themselves, and not be merely noted in a book.

Larvæ.

Persons residing in one place for any length of time can do great service by rearing insects from their larvæ. With many caterpillars this is often quite easy. Larvæ of unknown species, unless possessed of some remarkable feature, are of very little interest.

Larvæ or pupæ required for rearing, or for purposes of observation alive, are best carried in glass tubes or tin boxes. These must be kept as cool as possible, and not allowed to become too dry or too wet. Some dry green leaves will usually keep the atmosphere sufficiently moist, and at the same time will serve as foothold or for packing, as the case requires.

Larvæ of Hymenoptera and Coleoptera may be killed in boiling water, and after remaining in it from one to three minutes (according to the size of the larvæ) may be preserved in spirit.

Caterpillars, which lose their colour when preserved in spirit, may be killed in the cyanide-bottle or collecting-tin, and the skins preserved as dry specimens by means of the "larva-preserving apparatus" (*see* p. 67).

The contents of the body are removed thus :—The dead larva is laid on a piece of blotting-paper, with the tail farthest from the operator ; a pencil (or similar article) is laid across the tail end, and the contents rolled out of that part : this process is repeated, each time placing the roller a little nearer the head, until the whole body is emptied. Care should be taken, by shifting the position of the larva on the paper, not to let the outside of the skin get wetted. The roller must not be applied too heavily. A glass tube drawn out to a point is now inserted in the posterior opening of the skin, and held with the spring, and air is forced into it with the inflator, while the skin is held over the drying-apparatus or in the small oven. When dry the specimen is ready for mounting on a dry stem of grass or other suitable object. Care should be taken not to distend the skin unnaturally.

Preservation.

In damp climates great trouble is often experienced in keeping insects in boxes from getting mouldy, in which condition they are of little value. The risk of mould may, however, be entirely prevented by thoroughly rubbing the inside of the box into which the specimens are pinned with a piece of sponge, or swab of cotton-wool, soaked in a saturated solution of naphthaline in chloroform, mixed with an equal quantity of ordinary medical (beechwood) creosote.

The inside of the box should be rubbed with the mixture until the cork-lining shows through the paper. This method possesses the additional advantage of keeping away destructive insects. The fluid must not be allowed to touch the specimens, or they will be injured.

Methods of sending Specimens to the United Kingdom.

When collections are made in the Tropics, it is desirable to send home small consignments as early and as often as possible, and the parcel-post should be used wherever practicable. Strong wooden boxes * travel very well in this way ; but if pinned specimens are put in a box, *it must be enclosed in another rather larger one*, with cotton-wool or other material firmly (but not too tightly) packed round it. This precaution is necessary to prevent jarring in transit, which is liable to shake out the pins or to break the insects. Small boxes or bottles are always preferable to large ones, as an accident to one does not involve serious loss.

The greatest care must be taken to prevent specimens getting loose and rolling about in transit, and to prevent this all pins must be inserted as tightly as possible into the cork or pith with which the box is lined. Pinned specimens of the larger, heavier Coleoptera and Orthoptera should be kept in position by pins placed on each side obliquely. It is desirable to pin a piece of sponge dipped in strong carbolic acid in the box, taking care, of course, not to let the acid run on to the specimens. Lumps of camphor or naphthaline are *very dangerous* in a box with pinned insects, and should not be used, or if used at all should be enclosed in a muslin bag, and *very firmly* fixed in a corner of the box. Even these bags are very apt to get loose.

"Staged" insects should not be sent through the post ; it is better to pin them directly into the cork even when on short pins.

With the exception of Diptera and specimens with special data, almost all insects are better sent from the Tropics *unpinned*. For the larger, stouter species the best way is to use *coarse* sawdust

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* If cigar-boxes are used, they should be enclosed in a stouter larger box, as they are otherwise apt to be crushed in transit.

from which all fine dust has been sifted. Some naphthaline should be mixed with the sawdust, or, when there is risk of the specimens becoming mouldy, carbolic acid or creosote should be smeared inside the lid. The boxes or tins containing the

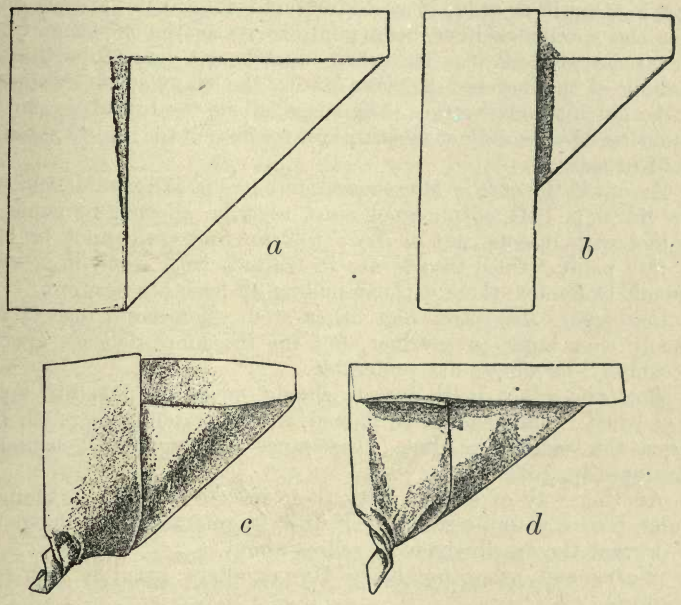

FIG. 26.—Diagrams to illustrate the construction of "Cushion" envelopes.

specimens in sawdust must be quite filled, otherwise the insects are liable to be injured by shaking about.

"Cushion" envelopes may be made of fairly thin *soft* paper as follows: Take a rectangular piece of paper of suitable size and write on it particulars of capture. Fold it as shown in fig. 26, *a*, *b*. Then, placing the forefinger of the right hand into the envelope

thus made (*b*), firmly twist the apex with the finger and thumb of the left hand so that a rigid pocket is formed (*c*). Into this, *one* insect should be placed and the pocket then closed by folding over the upper edge and passing the thumb-nail along the fold, so as to secure the insect firmly (fig. *d*).

When spirit is used, it is desirable to change it at least once after the specimens have been put into it, as the moisture from the insects weakens it. The spirit must bear a fair proportion to the bulk of the insects; in other words, too many specimens must not be put into one bottle. Any space left at the top of the bottle should be filled loosely with soft *paper* to prevent the insects shaking about in transit.

Except in the case of Microlepidoptera (*see* p. 77), and Mosquitoes (*see* No. 6, p. 104), cotton-wool must *never* be allowed to come in contact with insects, wet or dry; too much stress cannot be laid on this point. Once insects are in contact with wool, it is very difficult to remove them without pulling off legs, bristles, etc.

Coleoptera, *Hemiptera* and other stout, non-hairy insects are usually sent home in sawdust, but for the more delicate species "cushion" envelopes are preferable.

Bees and other hairy insects should never be put into spirit or sawdust. They should be pinned, if practicable (*see* pp. 69, 70). When this cannot be done, they must be put into "cushion" envelopes (p. 75).

Another way of dealing with these insects is to place them in match-boxes or pill-boxes, filled with fragments of tissue paper to prevent the specimens from rolling about.

Wasps and other non-hairy Hymenoptera may be put into sawdust.

Diptera.—See p. 79.

Lepidoptera should be put into triangular envelopes with their wings folded together over their backs. These envelopes may be made thus: Taking an oblong piece of paper (almost any sort will do), fold it as in fig. 27, then double one edge *up*, and the other *down*, as in fig. 28. The result is much greater convenience in opening than if both edges are folded in the same way. A stock of these envelopes, of different sizes, should be prepared ready for use.

The filled envelopes may be packed in biscuit-tins or strong wooden boxes, with some naphthaline ; this should not be scattered among the papers, but melted in a spoon and poured on the bottom and in the inside of the lid. If tins be used, extra care must be taken that the specimens are not damp when the tin is closed. It is important not to crush the specimens by putting too many into one box ; on the other hand, they must be sufficiently tightly packed to prevent them from shifting about.

It is recommended that " *Microlepidoptera* " should in all cases be pinned, the pin projecting sufficiently below the specimen to prevent injury by contact with the cork. The best pins for this purpose are those made from silver wire (obtainable from Messrs. Watkins & Doncaster, 36, Strand, London, W.C.2, at a cost of

FIG. 27.

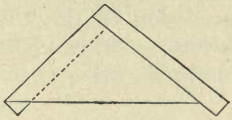

FIG. 28.

about 8*s*. 6*d*. per 1,000) : the sizes are known as " *Nepticula*, or *cap*." ; *Lithocolletis*, or 4/0 ; *Tinea*, or 0 ; *Tortrix*, or 1 ; *Large Tortrix*, or 3 ; *Xylo*., or 4 ; and two larger sizes, for special purposes, 5 and 6. *Tinea*, 0, and *Tortrix*, 1 and 3, will be found the most generally useful.

When the specimens cannot be pinned they should be arranged between thin layers of cotton-wool. The best preservative is Calvert's Carbolic Acid, No. 5 ; three or four lumps of Camphor dissolved in each bottle will increase its efficacy as a preservative and neutralise its caustic properties.*

Extra data are much needed even with the commonest species.

Neuroptera should if possible be pinned ; but if this is impracticable, they may be put into papers in the same way as Lepidoptera ; or they may be laid in chip-boxes, and kept from moving about by means of fragments of tissue-paper.

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* Camphor is not an antidote to Carbolic Acid, since both are narcotics.

Orthoptera required for study of structure may be put into spirit; but those intended for the dry collection are almost useless if they have been thus preserved. They should be dried quickly and put into sawdust. To preserve the colours of the larger Orthoptera, Neuroptera, etc., it is best where possible to starve them for a day or two before killing them. Sometimes these insects travel well in papers in the same way as Lepidoptera; but they must not be pressed. In the case of large-bodied species, such as Locusts, in a damp climate, it is advisable before placing them in papers to make an incision with a pair of fine scissors along the under side of the abdomen, and, after emptying it of its contents, to fill it with cotton-wool.

Bed-bugs, *Fleas*, *Lice* and other minute insects (as also *Ticks* and *Mites*), should be preserved and sent home in spirit (*see* p. 71). For transmission to the United Kingdom, the tubes containing the specimens should be packed carefully in cotton-wool, in a strong wooden or metal box.

Diptera (Two-Winged Flies),

With Notes on the Habits of the Perfect Insects and Larvæ.*

Articles Required.

(*See No.* 4. *Insects in General, pp.* 62–67).

A COLLECTING-TIN, zinc collecting-box, collecting-bottle, larva-preserving apparatus, and gum are not required for the collection and preservation of Diptera.

How to Distinguish Diptera from other Insects.

Apart from a few aberrant forms of small size, which are wingless, Diptera may be distinguished from all other insects † by the fact that they possess *only one pair of wings.* Thus, besides ordinary flies, such as Blue-bottles (*Calliphorinæ*) and House-flies (*Muscidæ*), the order also includes Midges (*Chironomidæ*), Gnats or Mosquitoes (*Culicidæ*), Daddy-long-legs (*Tipulidæ*), Horse-flies (*Tabanidæ*), etc.

How to Distinguish the Sexes.

In the majority of Diptera the sexes may easily be distinguished by the fact that the eyes meet together (or nearly so) on the

* For instructions for collecting *Mosquitoes* see "Instructions for Collectors, No. 6," pp. 98–107.

† With the exception of the winged males of Coccidæ (Scale-insects), from which they may be distinguished by the presence of a pair of little knobbed organs (the halteres or balancers) behind the wings, and the absence of filaments protruding from the hinder end of the body.

forehead in the male, but are more or less widely separated in the female. With the exception, however, of a few small families, this does not apply to the Orthorrhapha Nematocera [Gall-midges (*Cecidomyidæ*), Fungus-midges (*Mycetophilidæ*), *Chironomidæ*, *Culicidæ*, and *Tipulidæ*], the Diptera that are gnatlike in shape and possess long antennæ; neither is the character found in the Robber-flies (*Asilidæ*), the *Dolichopodidæ* (shining green, narrow-bodied, long-legged flies, usually found in the vicinity of water), nor in the vast army of Diptera (chiefly of small or moderate size) included in the families which it is customary to designate comprehensively by the term *Acalypterate Muscidæ*. In these cases, where no sexual distinction is furnished by the eyes, it is usually possible to determine the sex by an examination of the terminal segments of the abdomen: in the male the abdomen ends more bluntly, while the clasping organs are often very conspicuous; in the female the tip of the abdomen is generally more or less tapering, showing indications of the presence of an ovipositor, which is often extruded. In the Gnats or Mosquitoes (*Culicidæ* *) the sexes can readily be distinguished by the antennæ, which in the male are plumose, forming tufts in front of the head, while in the female they are nearly bare; in the Midges also (*Chironomidæ*) the antennæ in the male form plumes, while in the female they are quite short and inconspicuous. In certain families (*Dolichopodidæ*, *Empidæ*) secondary sexual characters are often furnished by the legs; where this is the case, it usually takes the shape of abnormal expansions of some of the tarsal joints in the male.

As a rule among Diptera *the sexes of the same species are alike in coloration*, or at any rate resemble one another pretty closely, striking sexual differences in this respect (such as are commonly seen among butterflies) being exceedingly rare; such differences are, however, exhibited by many species of the genus *Chrysops* (Tabanidæ).

When and Where to Look for Diptera.

With the exception of Gnats or Mosquitoes, Midges, and similar forms, Diptera are most active when the sun is shining. In hot

* For collecting this family, *see* No. 6, p. 98.

countries the hours from 8 o'clock till noon and from about 4.30 till sunset are usually the best for collecting. In England the best months for collecting are May, June, and July; but many species are to be found until late in September, while others occur in April or even in March: much of course depends upon the year, the season being sometimes a full month earlier or later than usual.

The following hints on collecting have been kindly furnished by Lieut.-Colonel J. W. Yerbury, who has had great experience in collecting Diptera both in the United Kingdom and abroad:—

"Diptera are to be found everywhere. Still, the following points should always be considered:—

"**Locality.**—In temperate climates virgin soil is best, with a south or west aspect for choice.

"In the Tropics shelter from the prevailing wind is the most important point.

"Shelter, however, is an important factor everywhere, and the line taken should be selected with due regard for the direction of the wind.

"**Habits.**—The habits of the various families differ greatly, and, as a natural consequence, their favourite localities vary also. Before discussing these in detail, it may be desirable to enumerate some of the general attractions for the order.

"*Flowers.*—Some flowers are particularly attractive to Diptera, and these are as a rule white or yellow in colour.

"In England the flowers of the following may be enumerated as specially attractive: common and Portugal laurel, holly, blackthorn, hawthorn, bramble, plane, barberry, and at times rhododendron and dog-rose; but the attraction of the two latter does not as a rule last long. Probably all these are equally attractive in Europe, and to them may be added dane-wort (*Sambucus ebulus*).

"In the Tropics Diptera should be looked for on the flowers of several palms and various species of Bher-trees (*Zizyphus*), etc.

"*Sugar*, as applied by Lepidopterists, has not as a rule much attraction. Still, occasionally it is attractive to Calypterate *Muscidæ*, and in a lesser degree to *Stratiomyiidæ*; while at

night many Daddy-long-legs (particularly *Limnobia*) come to sugar.

"*Ordure.*—Many Diptera are attracted by this — not only *Scatophaginæ* and *Muscidæ*, but Diptera of families which one would not expect to see, the moisture being the probable attraction.

"*Living Animals.*—Many species of *Tabanidæ* and other families are to be seen round living animals, but as a rule are not to be caught, the exception being the *Hippoboscidæ*, which can often be taken with ease. It is seldom possible to catch flies round animals, domestic or otherwise, with a butterfly-net ; but occasionally they can be caught with the hand, or boxed.

Dead Animals.—Carrion is sometimes very attractive, and many rare species not met with elsewhere are to be taken on it. Here again the moisture is probably the attraction. A place where blood has run over the ground is probably the attraction, though, strange to say, the wet mud and sand in river-beds, so attractive to butterflies in the Tropics, has no attraction for Diptera.

"*Other Attractions — Sweeping — Beating.* — Other attractions, such as leaves, tree trunks, bare sandy places, etc., had perhaps better be considered under the head of attractions to families. One method of capture should not be omitted, however, and this is *sweeping.* Many species of Acalypterate *Muscidæ*, and also many small *Syrphidæ*, which otherwise would probly be entirely overlooked, may be taken in this manner. The best places to sweep over are damp marshy spots, overgrown with rushes, flags, cotton-grass, etc. *Beating* seldom repays, though *Cyrtidæ* may now and again be obtainable by this means alone.

"**Habits of Various Families.**—*Syrphidæ* (Hover-flies, Drone-flies, etc.).—For this family sunshine is absolutely essential, and the majority will be found at flower heads, in company with many species of *Muscidæ*. Some few, however (*e.g. Xylota, Calliprobola, Brachypalpus*), prefer leaves and tree trunks ; while species belonging to certain genera (*Pelecocera, Melanostoma*, etc.) will probably be taken chiefly by sweeping. Many species of *Syrphus, Eristalis*, etc., may be taken hovering in the air.

"*Bombyliidæ* (Humble-Bee-flies, etc.).—The species of the

Anthracinæ branch of this family are generally to be found hovering in the hottest sunshine over, or resting upon, barren sandy or stony ground, bare spots on heaths, seashores, etc. The *Bombyliinæ*, on the other hand, affect flowers—*e.g.* primroses, *Potentilla*, etc. At Aden *Bombylius analis* was found hovering over the flowers of the garden turnip run wild, and probably other Cruciferæ will be found attractive.

"*Asilidæ* (Robber-flies) affect many and varied situations. Roads, bare sandy places, etc., are attractive to some species; others sit on tree trunks, stones, and telegraph posts and wires. Others, again, prefer dry sticks and branches near the ground;

FIG. 29.—LEUCOZONA LUCORUM.

FIG. 30.—BOMBYLIUS DISCOLOR.

FIG. 31.—ASILUS CRABRONIFORMIS.

while the species of *Damalis* and some few other genera love to sit on bare twigs about the height of one's eye.

"*Tabanidæ* (Horse-flies) are often to be seen flying round or settling upon living animals; but few are to be caught in this situation, most of the species of this family being taken flying round oneself or one's companions. A few may be caught sitting on tree trunks, leaves, walls, etc., and a few males taken hovering like *Syrphidæ* in the air.

"*Muscidæ Calypteratæ* may be met with in most situations. The species of many genera (*Idia* in particular) love flowers; others again (*Lucilia*, *Calliphora*, *Polietes*, etc.) are to be found round ordure and carrion. *Mesembrina* and *Rutilia*, in company with many species of *Anthomyinæ* and *Tachininæ*, love to sit on tree trunks, and prefer the sunny side.

"*Gastrophilinæ*, *Œstrinæ* and *Hypoderminæ* (Bot- and Gad-, or Warble-flies) are said to hover over mountain-tops. *Hypoderma*, however, is generally to be taken sitting on bare sunny places, in roads, heaths, etc. *Gastrophilus* is often to be seen round horses, and may sometimes be taken with a net; but it may be noted that it is labour wasted to attempt to catch specimens of this genus with a *white* net. *Cephenomyia* sits on stones in

FIG. 32.—TABANUS BOVINUS.

FIG. 33.—MESEMBRINA MERIDIANA.

FIG. 34.—GASTROPHILUS EQUI.

FIG. 35.—TRYPETA CORNUTA.

spots frequented by deer, and is said to settle not infrequently on human beings who enter its haunts.

"*Muscidæ Acalypteratæ* are to be taken as a rule by sweeping, though a few *Ortalidæ*, *Micropezidæ*, *Trypetidæ*, etc., may be captured on leaves and flowers, as well as on carrion and ordure.

"*Other Families.*—As regards other families, many of them will be met with while seeking for those already mentioned; and though the habits, etc., of the remainder are as varied as in the case of the latter, still the specimens encountered fortuitously will probably mount up to a considerable number."

Method of Collecting.

If possible, Diptera should always be brought home alive in glass-bottomed pill-boxes, or glass tubes, to which they are to be transferred on being captured in the net, and should then be killed in the cyanide-bottle or jar immediately before being pinned. As soon as a fly is taken in the net by a dexterous sweep, a sharp turn of the wrist must be given (following a smart downward or lateral stroke in order to bring the fly to the end of the net), in such a way that the end of the net containing the insect falls over the rim and so makes a closed bag from which it cannot escape. The end of the net can then be gathered up in the hand, and the fly forced into a still smaller space, in which it will not be difficult to get it into a pill-box or tube, and then to slip on the lid or insert the cork. If the specimens are small, it is possible with care to get several into one pill-box. Flies may also be transferred direct from the net to the killing bottle, and so brought home dead; but this method is not to be recommended, since prolonged exposure to the effects of cyanide of potassium is apt to injure the specimens, the ultimate condition of which, when thus treated, is rarely so satisfactory as if they had been brought home alive in pill-boxes. If, however, it is necessary for any reason to dispense with pill-boxes or tubes, and to use the killing-bottle in the open, a little crumpled tissue-paper should be placed inside it; this affords a lodgment for the specimens, and so lessens the risk of their being injured by rolling about. It may be noted that *Anthracinæ*, when placed in pill-boxes, are very apt to injure their wings by buzzing about, and large *Tabanidæ*, *Gastrophilinæ*, and certain other Diptera are liable to suffer in the same way. On the other hand, the hairy and scaly body-covering of *Anthracinæ* is very easily rubbed off, so that if carried in the killing-bottle they must be treated with especial care. It is always advisable when out collecting to carry a killing-bottle for use in case of need, in the event of the supply of pill-boxes or tubes running short. Diptera on windows may be captured in pill-boxes or tubes without difficulty, a piece of paper or thin card being used if necessary to close the opening until the lid can be slipped on or the cork inserted.

Spirit must not be used, except in case of Specimens intended for Dissection.

Unless intended for dissection, Diptera must *on no account* be placed in spirit. Since all descriptions of Diptera have been based upon *dried* specimens, flies in spirit have to be taken out, dried, and pinned before they can be examined and compared with descriptions. In drying, however, they invariably shrivel, while immersion in spirit often causes colour-markings to disappear, and inevitably results in hairs, scales, etc., being washed off or matted. *Specimens intended for dissection* (as when it is desired to examine some specially remarkable structure, such as the proboscis or genitalia) should, however, be treated in the following manner * :—The flies must be fixed by heat, since their chitinous envelope is penetrated so slowly by alcohol that, if this be not done, they decompose before the preservative can reach them. It is sufficient to bring them to boiling temperature in a test-tube of water, but for delicate histological work it is better to boil in a mixture of equal parts of 90 per cent. alcohol (ordinary rectified spirit) and aqueous solution of perchloride of mercury, 1 in 500. Even protozoal parasites are well preserved by this method. When fixed, preserve in 90 per cent. alcohol. *Methylated spirit* should *not* be used, since its acidity and other impurities may lead to embarrassment in the use of aniline stains. The specimens should be preserved in small glass tubes, with a plug of soft paper placed inside on the top of the specimens to prevent them from being injured by washing about. A slip of paper, on which all necessary data should be written clearly *in pencil*, should be placed *inside* each tube, and pinned specimens of the same species should be labelled with a reference to those in spirit, so that the latter may be identified. If it be intended to send Diptera thus preserved to England from the Tropics, the tubes containing the specimens should be preferably be placed for transmission inside a larger bottle of spirit ; if this be done, it is only

* The details of this method have been kindly supplied by Lieut.-Colonel G. M. Giles, I.M.S. (Retired), who has found that the process answers well in practice.

necessary to secure the mouth of each tube by tying muslin over it. Cotton-wool, or better still, horse-hair or shavings, should be inserted as packing between and especially on the top of the tubes. In order to decide, by means of dissection, questions as to the true diagnostic characters of species, or other problems, it is always desirable to possess *spirit* specimens of Diptera, even of species long since described, provided, as indicated above, that a pinned series of the same species be preserved.

Killing.

Diptera brought back alive after a day's collecting should be killed by being placed for a few minutes in the closed cyanide-bottle or jar. If the cyanide-jar is sufficiently large, the pill-boxes or tubes themselves may be placed therein, first opening them a fraction of an inch on one side to allow the cyanide to take effect. In the case of large sluggish Diptera, such as *Stratiomys*, the pill-box or tube may be opened without fear of the insect effecting its escape; after which a smart tap on the bottom of the receptacle will cause the fly to drop into the jar. Diptera should never be allowed to remain exposed to the effects of the cyanide longer than is necessary to ensure their being quite dead. If the poison is of reasonable strength, four or five minutes should be sufficient to kill even the largest and strongest flies; on the other hand, it is necessary to make sure that the insects are really dead, since, if the exposure to cyanide has been too short, flies will often appear to be dead when in reality they are only stupefied. As soon as the insects are really dead, they should be removed from the killing-jar; those in pill-boxes or tubes may be allowed to remain therein until one is ready to pin them, while the loose specimens should be turned out on to a sheet of cork-carpet or pith.

Methods of Preserving Diptera other than by Pinning.

Except when intended for dissection (*see* above), *Diptera should always be pinned*, and this should be done as soon as they are

dead. If preserved in any other way, they will never make satisfactory specimens.

When, however, it is impossible to pin them, Diptera may be preserved in fine sawdust, on which a few drops of medical (beechwood) creosote should be sprinkled to prevent mould. Each specimen, before being placed in the sawdust, should be loosely screwed up in fine tissue-paper (cigarette-paper would do), on which the necessary data (*see* below under "Pinning") should be written in pencil. To contain the specimens a small tin box (such as those in which tobacco is sold) should be used; and, to prevent injury from shaking, the box should be packed *quite full* of sawdust and specimens.

Diptera may also be put away for transport in three-cornered envelopes of soft paper (newspaper), after the manner in which butterflies are packed by collectors (*see* No. 4, p. 76); but this method, though it answers fairly well for *Tipulidæ*, does not suit thick-bodied flies, such as *Tabanidæ*, as these are often crushed by it, and if once flattened cannot be restored to their natural shape. Envelopes containing Diptera or other insects may conveniently be packed in tin tobacco- or biscuit-boxes for transmission by parcel-post from abroad. A few drops of dilute creosote should be sprinkled over each layer of envelopes, and the box should be packed quite full.

It is never advisable to put Diptera for transmission from abroad into small boxes containing wool, as when flies are once in contact with wool, and have become dry, it is very difficult to remove them without pulling off legs, bristles, etc.

Pinning.

Take a card disc, and write on it all the data connected with the specimen to be pinned, as follows: (1) name of *locality*,* including altitude if necessary; (2) *date*—day, month, year—thus 21.6.20; (3) *collector's name;* (4) any *brief remarks of interest*

* Should this not be likely to be found in an ordinary atlas, the name of the nearest well-known town, or river, bay, mountain, etc., or the approximate geographical position, should be added.

(which may if necessary be written on the other side)—*e.g.* " Very common " ; " Only specimen seen " ; " On dead antelope " ; " At —— blossom " ; " Running on banana leaves." *Longer notes* on habits, etc., should be entered in a note-book, with a number corresponding to one written on the disc. Specimens taken *in coitu*, for which a good look-out should always be kept when collecting, should have the fact noted on the disc of each, thus " A—*in coitu* with B " ; " B—*in coitu* with A."

Place the disc on which the above particulars have been written on a sheet of cork-carpet or pith, and, picking up with the forceps an entomological pin (a No. 20 if the specimen is not larger than a Blue-bottle, otherwise a No. 7), thrust it through the centre of the thorax of the specimen, until about ⅓ inch protrudes beneath. If the fly has rows of bristles on the thorax, care should be taken to insert the pin *between* them, and not to damage them in any way. Next grasp the pin with the forceps near the tip, and thrust it through the disc, then lift the latter and draw the pin well down. Lastly, thrust an ordinary pin, or a No. 11, through the disc near the margin for the purpose of carrying both disc and specimen, and draw the disc a good half-way up the carrying-pin.

The last thing to be done is to arrange the legs and wings so far as is possible. The wings must be made to project at an angle from the body, and not allowed to remain closed over it ; if they can be got to stay at right angles to the body, so much the better. In the case of any specimen that is not too small and fragile, the wings can best be arranged by means of the fine-pointed forceps, by making a gentle simultaneous pressure with the tips of the forceps at the base of each wing, repeating it until the wings assume the desired position. The legs also must be disposed symmetrically (and so far as possible in a natural position) on the card disc, so that all parts of them can readily be seen, and must not be allowed to remain crumpled up beneath the body, since important characters are often found on them. In the case of a specimen with strong claws (such as one of the Robber-flies) it will generally be found possible to cause the legs to remain in the desired position by hooking the claws on the edge of the disc, gently drawing the legs out one after another by aid of a needle or

one leg of the fine-pointed forceps. The manipulations in connection with the legs and wings must be performed as gently as possible, and care must be taken that bristles, hairs, or scales are not rubbed off in the process. As soon as these operations are completed, the specimen should be transferred to a store-box, or to one lined with cork-carpet or pith (*see* No. 4, p. 66). Since, however, the tissues contract in drying, the legs and wings are very apt to get pulled out of place, and, to correct these changes, the specimens should be examined once or twice during the next day or two after being pinned.

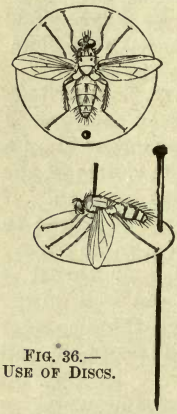

FIG. 36.—USE OF DISCS.

Very minute or fragile specimens are best *pinned from the side*, and the legs should then be straightened out by means of a No. 20 pin held in the entomological forceps.

Large discs (No. 4 gun-wad size—*see* No. 4, p. 67), carrying heavy flies, are very apt to swing on their pins, and thus to damage specimens alongside them, when store-boxes containing pinned Diptera are in transit through the post. To obviate this danger such discs should always be secured by firmly inserting into the floor of the box two or three common pins round each. When very small store-boxes are employed (*see* No. 4, p. 66) and space is an important consideration, the use of discs may be omitted altogether. In such cases, pinning and the arrangement of legs and wings must be carried out on the lines already laid down, particular care being taken to ensure that specimens are *as high up on their pins as possible;* the data mentioned on the previous page must be attached to each specimen in the form of a label, or when the same data apply to a number of flies, the details may be written on the floor of the box.

DIPTERA COLLECTED IN THE TROPICS: ATTACKS BY ANTS—MOULD—TRANSMISSION TO ENGLAND.

In the Tropics and hot countries generally, boxes of pinned insects are very liable to the attacks of minute *ants*, which, if they

once gain access to a box unobserved, will soon play havoc with its contents. In Brazil it has been found that ants can be prevented from entering insect-boxes by smearing the outside round the line where the box opens, or any other possible place of entrance, with *andiroba* oil, repeating the process as often as necessary; similar methods might be employed elsewhere in case of need. An even more certain mode of securing immunity from ants is to stand the legs of a table on which insect-boxes are kept in vessels (*e.g.*, tobacco tins) containing water. The table legs must not touch the sides of the vessels, and the top must nowhere be in contact with a wall. To prevent mosquito-breeding, the water in the vessels, which must not be allowed to evaporate, should be kept covered with a thin film of paraffin.

Mould, however, is an even greater enemy to collections of Diptera. Unless precautions (*see* No. 4, p. 73) be taken, pinned specimens of Diptera, like those of other insects, rapidly develop mould during the rainy season in tropical countries; mouldy specimens are practically worthless for purposes of scientific determination, and, even when protected in the manner referred to, *Diptera should always be sent home as soon as possible after being collected.*

The greatest care must be taken to prevent specimens from getting loose and rolling about in transit, since in this way a single loose disc might easily do irreparable injury to many other specimens in the box. To obviate this, the pins supporting the discs should be inserted as tightly as possible into the cork-carpet or pith, and they should all be driven in to the same level, after which a sheet of soft paper (newspaper does very well) can be *fixed* into the box, resting on the heads of the supporting pins, in order to minimise the damage should a disc happen to get loose. The box containing the specimens should be well wrapped in cotton-wool or similar material, and firmly *packed in an outer case* for transmission (by parcel-post if possible and if the package is not too large) to England.

Number of Specimens of each Species required.

At least half a dozen specimens of *each sex* of a species should, if possible, always be obtained, and a good look-out should be

kept for specimens showing any abnormality in structure, coloration, or size. When the collector remains long enough in one spot, he should always endeavour to obtain specimens of a species on different dates, in such a way as to throw as much light as possible on the duration of its seasonal occurrence, or the possibility of there being more than one brood in the year. Similarly the attempt should be made to illustrate the geographical range or local distribution of a species by collecting specimens in as many different localities as possible. Specimens of species taken in new localities, though common elsewhere, are always valuable.

Larvæ and their Habits.

The habits of Dipterous larvæ are as varied as the outward appearance of the larvæ themselves. The latter may be met with almost everywhere, but especially in decaying matter of all kinds, in water both running and stagnant, in the ground, attacking the roots and bulbs of plants, or mining in the stems and leaves. It is worth noting, especially as a means of distinction from Coleopterous larvæ, that *no Dipterous larva is possessed of true (thoracic) legs*, though in many species (*e.g. Tabanidæ* and those belonging to the genera *Eristalis* and *Helophilus*) pro-legs or transverse ridges having a similar function are distinctly visible.

The following notes as to the mode of life of the larvæ of some of the best-known families of Diptera may be useful :—

The tiny pink- or scarlet-coloured grubs of the Gall-midges (*Cecidomyidæ*), as their name implies, form galls on the leaves and stems of plants.

The white grubs of the Fungus-midges (*Mycetophilidæ*) have black heads, and are to be found for the most part in fungi and boleti.

The larvæ of *Bibionidæ*—a family that includes "St. Mark's fly" (*Bibio marci*, L.) and other species of black flies, which in England are exceedingly common in meadows in spring and early summer, sometimes hovering in the air, dancing in swarms, or feeding on the heads of Compositæ—are similar in appearance to those of Fungus-midges, and may be met with in vegetable mould, or in the droppings of cattle.

The greenish or brownish, somewhat leech-like larvæ of the

Simuliidæ—a family in which the females of all species are vicious blood-suckers—may be found (with the pupæ) in rapidly-flowing brooks and streams, adhering, sometimes in almost incredible numbers, to the submerged surfaces of stones or water plants.

The mode of life of the larvæ of the true Midges (*Chironomidæ*) is somewhat varied, those of the genus *Chironomus* being aquatic (the well-known "blood-worm," so common in rain-water, is the larva of *Chironomus plumosus*, L.); the tiny, eel-like larvæ of the genus *Culicoides*, which includes a number of blood-sucking Midges, are found in pools, or puddles; the larvæ of *Clunio* are marine, living in rock-pools and feeding on green sea-weed (*Cladophora*).

FIG. 37.—BIBIO MARCI, ♀, WITH HEAD OF ♂.

FIG. 38.—CHIRONOMUS PLUMOSUS.

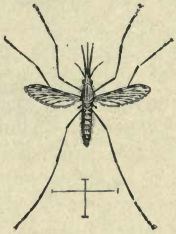

FIG. 39.—ANOPHELES MACULIPENNIS.

The exceedingly active larvæ and pupæ of Gnats or Mosquitoes (*Culicidæ*) are exclusively aquatic, and are to be found in ponds, tanks, or butts of rain-water, in marshes or the shallow expansions at the sides of streams, in rot-holes in trees, and also, in the case of those of certain species, in open drains and cesspools; in the Tropics, in casual accumulations of water in old tins, bottles, calabashes, etc. (*Culicinæ*, *Stegomyia*), or in stagnant or nearly stagnant water in pools, at the side of rapid or slowly flowing streams, or in permanent puddles (*Anophelinæ*).*

* For further information as to the life-history of mosquitoes, *see* "Mosquitoes and their relation to Disease, their Life-History, Habits and Control." By F. W. Edwards, B.A. London: Printed by Order of the Trustees of the British Museum. 2nd Ed. 1920. Price Fourpence.

The grub-like larvae of Daddy-long-legs (*Tipulidæ* and *Limnobiidæ*) live for the most part in rotten wood, in water, or in the soil. The grubs known as Leather-jackets, so destructive to the roots of turf and sometimes to cabbages, are the larvae of *Tipula paludosa*, Mg., and *T. oleracea*, L.

The larvæ of *Stratiomyiidæ* have a hard, armourplate-like integument, and live in water or in humus: the aquatic forms are elongate, flattened dorso-ventrally, and have a somewhat leech-like appearance.

The voracious larvæ of the Horse-flies (*Tabanidæ*) are whitish,

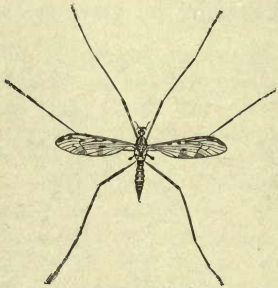

FIG. 40.—LIMNOBIA NUBECULOSA.

FIG. 41.—STRATIOMYIA FURCATA.

soft-bodied grubs, which are provided with circlets of protrusible pro-legs, and are to be found in water or mud.

The white elongate larvæ of Robber-flies (*Asilidæ*) are likewise carnivorous, preying upon other larvæ, and occur in earth, sand, or rotten wood.

The larvæ of the Humble-Bee-flies (*Bombyliidæ*) are parasitic in the nests of solitary bees, or in the egg-capsules of locusts and grasshoppers.

The habits of the larvæ of the *Syrphidæ* are exceedingly diversified: those of the true Hover-flies (*Syrphus*) may be found on leaves infested with *Aphidæ*, upon which they feed; those of *Volucella* are inquilines in the nests of humble-bees and wasps; the well-known "Rat-tailed Maggots" (such as the larva of

the Common Drone-fly, *Eristalis tenax*, L.)—so called from the protrusible, telescopic, terminal segments of the body, which carry the breathing-tubes—live in decaying animal or vegetable matter in a liquid or semi-liquid state, in foul and stagnant water, drains, and similar places; the larvæ of other genera (*e.g. Brachypalpus*, *Xylota*, *Calliprobola*) live in rotten trees. The larvæ of *Syrphidæ* in general (including all the foregoing) are more or less soft and grublike in appearance; but those belonging to the genus *Microdon*, which live in ants' nests, have a hard, dorsally convex shell, without or with scarcely a trace of segmentation, and are so aberrant in appearance as to have been mistaken for molluscs.

The larvæ of the Bot-flies and Gad- or Warble-flies (*Gastrophilinæ*, *Œstrinæ*, and *Hypoderminæ*) are *Mammal parasites*. They are white and grub-like in shape, and live in the stomach and intestine, nostrils, frontal sinuses, pharynx, or beneath the skin. The majority are parasitic upon Ungulates; but the larvæ belonging to the American genus *Cutiterebra* are found beneath the skin of Rodents. It may be noted that larvæ belonging to these sub-families rarely survive forcible removal from the host. Pupation invariably takes place upon or in the ground, under stones, etc.; therefore, in order to breed out the perfect insects, an attempt should be made to obtain the larvæ as they leave the host in order to pupate, or the pupæ themselves should be sought for in the situations indicated, in places frequented by the animals. In the case of domestic or other animals, kept in captivity and infested by these parasites, the pupæ or larvæ about to pupate may sometimes be obtained by searching in the stalls or sheds at the proper season. According to Brauer, the majority of Bot- or Warble-fly larvæ leave their hosts in the early hours of the morning.

The larvæ of the *Tachinidæ* (*sensu latiore*) and *Muscinæ* are well known as *maggots*, and are to be found in decaying matter of all kinds, and even in festering sores and wounds on living animals; those of the sub-family *Tachininæ* are parasitic in other insects—the majority in caterpillars.

The habits of the larvae belonging to the families constituting the "*Acalypterate Muscidæ*" are too diversified to be dealt with in detail. Some are to be found in ordure; others attack the

stems of grasses and cereals; while the larvæ of others again (*e.g. Trypetidæ*) live in fruits, in seed-heads, in galls on the stems, or mine in the leaves of various plants.

The larva of *Conopidæ* are parasitic in the bodies of imagines of Hymenoptera (and Orthoptera*).

How to Preserve Larvæ.

Specimens of Dipterous larvae are always valuable, whenever it is possible to breed out some of them so as to determine the fly to which they belong. Unless, however, the perfect insect be known, it is rarely possible to do more than to assign a larva to its *family*. Larvæ for preservation should be killed by immersion

Fig. 42.—Fabriciella ferox.

Fig. 43.—Conops flavipes.

for *a moment or two* in boiling water, and should then be placed in weak spirit (two-thirds strong spirit and one-third water); after being allowed to remain in this for two or three weeks until thoroughly hardened, they can be transferred to stronger spirit. The larvæ of each species must of course be kept separate, and should be put up in a small, corked glass tube full of spirit, the necessary particulars, with, if possible, a reference to pinned specimens of the perfect insect, being written in pencil on a scrap of paper and placed *inside*.

Notes on Habits, etc.

Very little is yet known as to the habits of Diptera in general, so that notes on the habits, distribution, seasonal occurrence,

* *Physocephala vittata*, F., was bred by Boheman from a grasshopper, *Sphingonotus cyanopterus*, Charp.

relative frequency, etc., of particular species will always be of great value and interest.* Particular attention should be paid to the habits of *blood-sucking species*† and others of economic importance. A good look-out should also be kept for cases of *mimicry* between Diptera and Hymenoptera, which will be found to occur chiefly among the *Syrphidæ* (to a lesser degree also among the *Asilidæ*). The *Syrphidæ* as a family may be said to mimic Hymenoptera, but in some genera—*e.g. Volucella, Arctophila, Calliprobola*—the resemblance is especially pronounced. Instances of mimicry between Diptera and insects belonging to any order other than Hymenoptera are exceedingly rare. *Cases of mimicry between particular species* should be specially noted.

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* For special points in connection with Mosquitoes as to which information is desired, *see* No. 6, p. 98.

† For notes on *Blood-Sucking Flies*, *see* No. 7, p. 108.

Mosquitoes (*Culicidæ*).

Systematic Position, Distinctive Characters, and Life History of Mosquitoes.

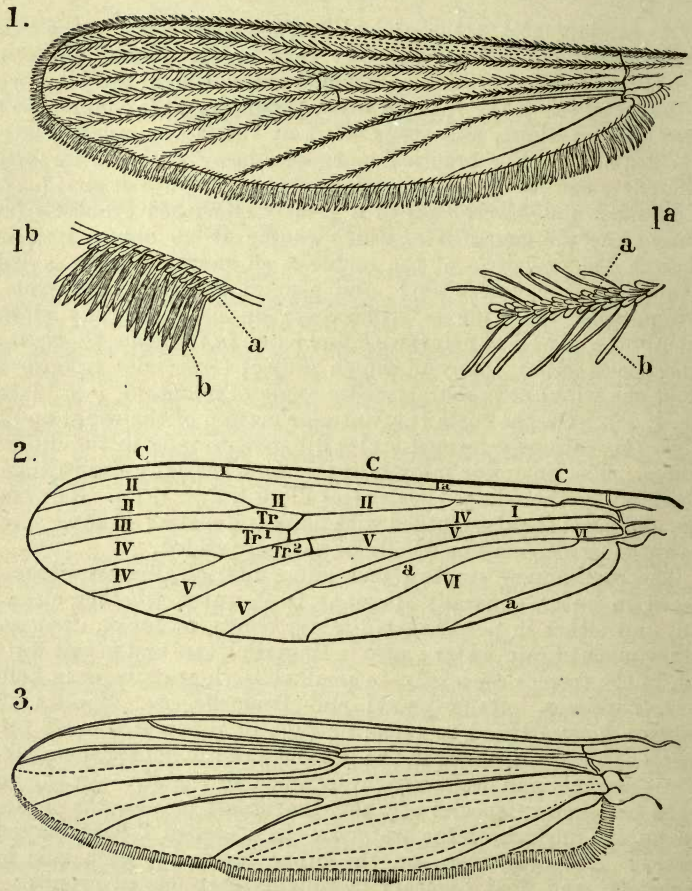
"Mosquitoes" or "Gnats" (strictly speaking, the terms are synonymous) are the names popularly applied to the family *Culicidæ*, of the order of insects known as Diptera (*Two-winged* Flies),* which also includes, besides other families the species of which are more or less gnat-like in form, such as the true midges (*Chironomidæ*), fungus-midges (*Mycetophilidæ*), daddy-long-legs (*Tipulidæ*), etc., a large number the members of which are more "fly"-like in shape, *e.g.*, the blue-bottles and house-flies (*Calliphorinæ* and *Muscidæ*) tsetse-flies (*Glossina*), horse-flies (*Tabanidæ*), hover-flies (*Syrphidæ*) etc.

Culicidæ are by no means the only blood-sucking Diptera (for the other families in which the blood-sucking habit occurs *see* "Instructions for Collectors No. 7," p. 108). The other blood-sucking Diptera, however, with the possible exception of *Culicoides*, are sufficiently distinct from *Culicidæ* in outward form to obviate any risk of confusion. In countries in which mosquitoes abound they are recognized without difficulty, but in England, where some six and twenty species of the family occur, a large amount of confusion apparently exists as to the characteristics of a mosquito, or, as it is more commonly called, a gnat. This confusion is mainly due to the fact that the midges (*Chironomidæ*), which, with the exception of a few genera, such as *Culicoides*, are perfectly harmless, often attract attention from the habit of the males of dancing in the air in swarms on fine evenings in late spring and early summer and, owing to their similarity in shape, size, and general appearance, are commonly mistaken for gnats (*Culicidæ*).

* *See* No. 5, p. 79.

A fundamental structural difference between *Culicidæ* and *Chironomidæ* consists in the fact that in the former the costal vein (Plate I, fig. 2, *c*) runs right round the margin of the wing, while in the latter (as in the vast majority of Diptera) it is confined to the front margin alone, and stops short at the tip (compare Plate I, figs. 2 and 3). For practical purposes, however, more important differences consist in the possession by the mosquito or gnat (except in *Corethra* and *Mochlonyx*) of a greatly elongated proboscis (containing the piercing-stilets, which enable it to obtain its food), whereas the proboscis of the midge is so short as to be invisible without close examination; and also in the fact that while in *Chironomidæ* the wing is either bare or else uniformly clothed (membrane as well as veins) with fine hairs, *in Culicidæ, the veins are clothed with scales*, many of which project (especially towards the tip of the wing) at a characteristic angle of about 45° (*see* Plate I, figs. 1, 1[a]). On the costa (*i.e.* anterior margin of the wing) and the veins, the variously formed scales differ materially in the different groups. The posterior margin of the wing carries a deep fringe of elongated, feather-shaped scales (*see* Plate I, figs. 1, 1[b]). The body, legs, and palpi are also clothed with hairs and scales; in some species the antennæ also may be wholly or partially scaled.

The preliminary stages (larva and pupa) of all mosquitoes are passed in water, generally stagnant fresh water, whether clean or foul, and either in permanent ditches, ponds, or tanks, or in temporary pools of rain-water; also in sluggish rivers and in salt water; and, in the tropics especially, in small collections of water in hollow trees, bamboos, pitcher-plants and Bromeliaceae. Species that frequent houses breed in butts or tubs of rain-water or in other vessels of water within or in the precincts of the houses themselves, or in cesspools and wells which are open to the air. In the case of the best-known species of *Culex* that infest houses, the eggs are laid on the surface of the water in the so-called "boat-shaped" masses; *Anopheles* eggs, on the other hand, are as a rule laid separately, and float together in roughly star-shaped groups; in the case of certain species, however, the eggs are arranged side by side in "ribands"; in *Aëdes*, *Ochlerotatus* and *Stegomyia* they are laid separately. The eggs of the different genera vary much in form.



THE WING OF A MOSQUITO OR GNAT (*Culex sp.*) AND OF A MIDGE (*Chironomus plumosus*).

PLATE I.

Explanation of Plate I.

Fig. 1. Wing of a gnat or mosquito (*Culex sp.*), × about 16.

1[a]. Portion of 2nd longitudinal vein, greatly enlarged, to show the covering of scales : (*a*) median vein-scales ; (*b*) lateral.

1[b]. Portion of hind margin of wing, greatly enlarged, to show the fringe : (*a*) border scales ; (*b*) fringe-scales.

Fig. 2. The same wing denuded of hairs and scales, to show the course and nomenclature of the veins.

C. costal vein (in *Culicidæ* this runs right round the margin of the wing) ; the anterior margin of the wing is called the costa.

I[a],	sub-costal vein.	(Sc) Subcosta.	
I,	1st longitudinal vein.	(R_1)	Radius.
II,	2nd ,, ,,	(R_2 and R_3)	Radius.
III,	3rd ,, ,,	($R_4 + R_5$)	Radius.
IV,	4th ,, ,,	(M_1 and M_2) Media.	
V,	5th ,, ,,	(Cu_1 and Cu_2) Cubitus.	
VI,	6th ,, ,,	(An) Anal.	

a, wing-folds or pseudo-veins.

Tr, supernumerary cross-vein (base of third longitudinal, R_{4+5}).

Tr[1], mid cross-vein (Radio-Medial, R-M).

Tr[2], posterior cross-vein (Medio-Cubital, M-Cu).

It will be observed that the 2nd, 4th, and 5th veins are forked (the branch nearer the costa is spoken of as the *upper*, that nearer the hind margin of the wing as the *lower* branch in each case). The relative lengths of the forks of the 2nd and 4th veins vary in different genera and species.

Fig. 3. Wing of a midge (*Chironomus plumosus*, L.), × about 12, showing that the veins are destitute of scales.

The mosquito larva is usually a small greenish, greenish-brown, or brown creature, occasionally red and blue, with a round head, a rounded swollen thorax, and an elongated jointed abdomen, from near the end of which, in all except *Anopheles*, the breathing-tube arises. In the pupa the head and thorax are fused into a mass, on the sides and front of which depend the rudiments of the wings, legs, and proboscis of the future adult insect, while from the dorsal side project a pair of funnel-shaped breathing-organs ; the terminal segment of the abdomen bears a pair of swimming-plates. The larvæ and pupæ are exceedingly active, moving about in the water by a jerking or wriggling motion of the body ; with certain exceptions, they are under the necessity of coming to the surface to breathe at frequent intervals. The larva of *Anopheles* floats horizontally at the surface of the water, and is devoid of a prominent air-tube.

In the case of *Culex fatigans*, Wied., it was found by Howard, in the United States, that the minimum time occupied by the whole life-history cycle was ten days—" namely, sixteen to twenty-four hours for the egg, seven days for the larva, and two days for the pupa." But the period necessary for a generation "is almost infinitely enlarged if the weather be cool," so that it is also permissible to suppose that it is accelerated by heat.

In the perfect state the male insects die quickly in confinement, but the females are longer-lived. *Stegomyia fasciata* has been kept in confinement for so long as 154 days ; while females of the single-brooded species of *Ochlerotatus* may live even under natural conditions throughout a whole summer. In cold climates the perfect insects of some species pass the winter in a state of hibernation, but other species winter as larvæ (*Anopheles bifurcatus*) or as eggs (*Ochlerotatus*).

List of Articles Used for Collecting and Preparing Mosquitoes.

One entomologist's collecting-net of book-muslin (one or two spare net-bags may be taken, in case the one in use gets torn).

A smaller net for collecting larvæ in ground pools.

A good-sized pipette for collecting larvæ in tree-holes, etc.

A number of glass-*bottomed* pill-boxes (1–1½ inches in diameter is about the best size).

Other requisites (details as to which will be found in No. 4, pp. 62–67) are :—Cyanide killing-jar ; chloroform ; entomological forceps ; entomological pins, Nos. 20 and 11 ; sheets of transparent celluloid for cutting into mounts (*see* Instructions for Collectors, No. 4, p. 71) ; two or three needles mounted in handles ; a platyscopic lens ; one or two sheets of cork-carpet or pith ; an entomological store-box (or adapted cigar-box) ; medicated cotton-wool for packing mosquitoes in pill-boxes when time does not allow pinning ; a number of glass tubes for preserving larvæ and pupæ.

Importance of obtaining Specimens for Determination and Description in the best possible Condition.

It should be borne in mind that, for the purpose of the scientific determination of species, *mosquitoes cannot be collected with too great care.* As important specific characters are furnished by the *scales, wings,* and *legs,* it is of the utmost consequence that the scales should not be rubbed off, nor the wings and legs injured. *Unless attention is paid to this point the specimens will probably be quite worthless for determination or description.*

Number of Specimens of each Species Required.

In collecting specimens of a species of mosquito for determination, some *dozen* examples of *each sex* should, if possible, always be obtained and pinned or preserved dry.

How to Distinguish the Sexes.

The male mosquitoes can usually be distinguished from the females (which alone bite and suck blood) by the possession of plumose antennæ, forming tufts in front of the head (in certain genera, such as *Deinocerites* and *Sabethes,* the male antennæ are not plumose ; the genitalia must then be examined) ; in the females the antennæ, though long, are less hairy (having whorls of shorter hair at the bases of the joints), while the palpi in the case of females

are quite short, except in the genera *Anopheles* (in which the palpi are as long as the proboscis in both sexes, but are more swollen at the tips in the males), *Megarhinus* and *Leicesteria*.

In some genera the palpi are short in both sexes, but the plumose male antennæ will separate male from female. It is particularly desirable that males be collected and kept together with their females.

Method of Collecting and Killing.

Mosquitoes may be captured in the open; an entomologist's collecting-net is then necessary, from which the insects can be transferred to glass-bottomed pill-boxes. In doing this great care must be taken not to pull off the legs. Inside buildings mosquitoes can easily be captured on walls and windows in the pill-boxes themselves. Specimens are, however, best obtained in good condition by *breeding* them; this can readily be done by keeping the larvæ or pupæ in a basin or jar of water covered over with book-muslin. Bred specimens should, if possible, be kept for twenty-four hours before being killed, to allow their bodies to harden. In any case mosquitoes are best collected alive in the glass-bottomed pill-boxes. Not more than a single specimen should be put alive in each box. To kill the mosquitoes the box is opened a fraction of an inch on one side, and placed for a few minutes in a cyanide killing-jar, which must, of course, be closed. They may also be killed by tobacco smoke or chloroform; a drop of the latter on a scrap of paper inserted into the box will take effect in a minute or so. If cyanide or tobacco smoke is used, specimens should not be left in the fumes more than ten minutes. As soon as the insects are quite dead they should be turned out on to a sheet of cork-carpet; they should be touched as little as possible, the manipulations necessary for arranging the wings and legs being performed with a needle.

When travelling, and time and space are of importance, mosquitoes need not be pinned, but may be collected in pill-boxes and kept firm by *medicated* cotton-wool. Glass-topped boxes of metal are best for tropical climates. The gnats should be placed, when killed, on the glass, and then a loose plug of medicated cotton-wool placed on them, so as to prevent them from shaking about.

Pinning and Mounting.—Specimens should be Pinned immediately after Death.

Mosquitoes are best pinned as soon as possible after death, and in two positions so as to show (1) the dorsal view, (2) the lateral aspect.

When specimens are collected for transmission to England, mounting is unnecessary—in fact, inadvisable, since mosquitoes travel home with very much less risk when pinned directly into the bottom of the collecting-box. No particular trouble need be taken in arranging the legs and wings, but, whenever possible, some specimens should be pinned through the side of the thorax, others from above. If only one or two specimens are available, they are best pinned from the side. Pinning must be very carefully done, and the less the specimens are touched the better.

It is, of course, essential to record all the data connected with the specimen—locality and date of capture, collector's name, and any remarks of interest. These particulars may either be written on the bottom of the box or on labels pinned below the specimens.

If it is desired to mount the insects, they may be staged on rectangles (about 10 by 15 mm.) of transparent celluloid. A fine puncture should first be made with the tip of a Tayler's No. 11 pin; this pin should then be pushed through the opposite end of the mount, and finally the fine pin, bearing the specimen, inserted through the small hole previously made. Labels, with full data, should be attached to the strong pin.

Preservation of Larval Skins.

Very important differential characters are found in the larvæ and pupæ, especially the former, and as these characters are all retained by the cast skins, it is very desirable that these should be preserved when specimens are bred.

The full-grown larvæ should be isolated in separate tubes, lightly plugged with cotton-wool. As soon as the larva pupates, its skin should be transferred to a small tube of spirit, to which the pupal skin can be added on the emergence of the adult. The

skins may either be sent home in the tubes, or mounted in balsam on slides in the ordinary way.

Care should, of course, be taken to see that the skins and the issuing adult bear corresponding numbers.

Preservation of Larvæ and Pupæ.

Specimens of larvæ and pupæ should always be preserved, especially when it is possible to breed some of them out, or otherwise to determine the species to which they belong. They should be killed and kept in alcohol or formol.* If in alcohol, its strength should be about 70 per cent.

Of formol a 4 per cent. solution (*i.e.*, one part of ordinary commercial 40 per cent. solution to nine parts of water) is quite strong enough for killing and preserving.

Larvæ and pupæ (whether preserved in formol or alcohol) should be put into small glass tubes, which should be corked; the corks may be coated with paraffin wax, though this is not absolutely necessary. Each tube should contain a scrap of paper, on which the necessary data (locality, date, whether from fresh or salt water, collector's name, etc., with, if possible, a reference to pinned specimens of the perfect insect, so that these may be identified) should be written in pencil.

The tubes should be packed in cotton-wool in a small tin box for transmission to England.

It is scarcely necessary to add that each species should be kept distinct, in a separate tube.

Observations on Habits, Distribution, etc.

Detailed observations on the habits, distribution, seasonal occurrence, etc., of mosquitoes will always be useful, provided that care is taken to note the species to which they apply—the species being distinguished by means of letters or numbers written on the under sides of the discs to which the specimens are pinned.

While it is probable that in a natural state only an infinitesimally

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* Otherwise known as formaldehyde or formalin.

small proportion of all the mosquitoes that come into existence can possibly taste the blood of a warm-blooded animal, it is reasonable to suppose that primitively all *Culicidæ* fed upon the juices of plants ; some species are still exclusively vegetarian in both sexes ; in others, while the males are vegetarian, the females suck animal blood—in some species only exceptionally, in others habitually. These characters should be noted.

The breeding habits, especially the oviposition, of many mosquitoes are still unknown, and valuable work can be done by investigation upon this subject.

The countries whose mosquito faunas are least known are New Zealand, New Guinea, and Madagascar. The British Museum is also in special need of collections from Europe and Australia.

Protection from Mould of Specimens Collected in the Tropics.—Transmission to England.

For directions under these headings, *see* Instructions for Collectors, No. 5, p. 90.

Instead of pinning mosquitoes into store-boxes, or cork- or pith-lined cigar-boxes before sending them by post, a method preferred by some collectors, which has much to recommend it, is to transmit the specimens in glass tubes about an inch in diameter. Narrow strips of cork carpet, previously coated with white paper, and cut to the length of the tubes, are fixed to the cork by two pins inserted diagonally. Data concerning the specimens are written on the cork carpet strip, and the specimens are then pinned on to it. In order to allow the escape of moisture from the specimens while the latter are drying, a small wedge should be cut out on one side of the cork and the hole plugged with cotton-wool.

Blood-sucking Flies.

Notes on Blood-sucking Flies, other than Mosquitoes.

(For the *distinctive characters of Flies* (Diptera), as compared with other insects, *see* No. 5, p. 79.)

Blood-sucking Flies: Their Appearance, Life-history, and Habits.

With the exception of the Gnats or Mosquitoes (*Culicidæ, see* No. 6, pp. 98–107), blood-sucking species of Diptera occur, so far as at present known, only in the following families :—Chironomidæ, Blepharoceridæ, Simuliidæ, Psychodidæ, Tabanidæ, Leptidæ, Muscidæ, Hippoboscidæ. The enormous majority of Blood-sucking Diptera belong to the family Tabanidæ (Horse-flies or Dun-flies, Clegs, Serut-flies), in which the blood-sucking habit is universal (or practically so) in the female sex ; in the other families enumerated, if we exclude the Simuliidæ and Hippoboscidæ, the habit is exceptional, and the species concerned are comparatively few. As a rule, the blood-sucking habit is confined to the females.

Chironomidæ (Midges : in India and Australia called *Sand-flies*) :—genus *Culicoides* and its allies.

The blood-sucking species at present known are confined to the subfamily *Ceratopogoninæ*,* which is represented throughout the world, and at the present time comprises between four and five hundred described species. The blood-sucking habit, however, is by no means universal even among *Ceratopogoninæ*, and is limited to the female sex, and almost entirely to the genus *Culicoides* and one or two small allied genera.

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* One of the Tanypodinæ (*Trichotanypus tiberiadis* Kieffer) has been recorded (probably in error) as sucking blood in Palestine.

Appearance.—Extremely small flies, as a rule (in the case of species known to suck blood), not exceeding 1½ or 2 mm. in length, though the males are usually somewhat larger than the females; generally blackish or dark greyish-brown in colour, but the abdomen of the female, after feeding, often rosy, owing to the contained blood. The wings when at rest are carried flat, closed one over the other like the blades of a pair of scissors; in many species they are hairy, and they are often speckled or mottled with greyish-brown blotches. The sexes can be distinguished by the males having tufted antennæ and a more elongate shape.

Life-history.—The larvæ of naked-winged *Ceratopogoninæ* and those of *Culicoides* are generally aquatic, those of other hairy-winged species terrestrial. The eggs of aquatic species are laid in floating algæ, in star-shaped clusters containing from one hundred to one hundred and fifty eggs. The larvæ of these species are whitish worm-like creatures, with long narrow heads, and live in the masses of Confervæ floating on the surface of stagnant pools and ditches, but in some places and under certain conditions may often be seen swimming freely. They are without prolegs on the prothoracic segment, and progress with a serpentine motion. The pupa, which is shorter than the larva, with a conspicuous pair of respiratory horns on the thorax, is brownish in colour, possesses little power of movement, and remains at the surface of the water. The larvæ of the hairy-winged species live under the damp bark of dead trees, in weeping spots on tree-trunks, and in decaying vegetable matter generally, such as manure, rotting fungi, etc. These terrestrial larvæ are usually shorter than the aquatic ones, and do not move in serpentine fashion, but are provided with a cleft proleg on the under side of the prothoracic segment, while the head and body-segments also bear peculiar lancet-shaped hairs and spines. Serpentiform larvæ, which have produced midges with hairy wings, have, however, been found in the sap saturating diseased bark on tree-trunks.

Habits of the perfect insects.—In spite of their small size, the females of certain species of *Culicoides* are among the most irritating and bloodthirsty of insects, both in the tropics and also in temperate regions. Writing of a species (perhaps *C. grahamii*,

Austen) found in Uganda an observer * says: "It is very common in many places, usually near habitations. This minute fly can pass through the finest mosquito netting; muslin I have not tried. It bites terribly, leaving an irritating wheal, which itches for days. It makes a sharp, short, peevish buzz when settling, fully as loud as a mosquito. It attacks the wrists chiefly, but is able to pass beneath a sheet, and bite the ankles and feet. Many were frequently found full of blood on turning down the bed-clothes. I have met with a similar fly, with the same habits, at Ahmednuggar (Bombay Presidency), India." In some places, at any rate, midges torment domestic animals in addition to human beings. *Oecacta furens*, Poey, which is found in Cuba (where it is known as the *jejen*), and is said also to occur in Jamaica and Mexico, chiefly haunts wooded spots near the sea, and is a scourge of man and animals: in New Mexico *Tersesthes torrens*, Towns., has been caught attacking horses.

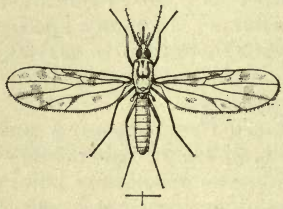

FIG. 44.—*Culicoides brucei*, Austen, ♀. Uganda. (× 12.)

Blepharoceridæ:—genus *Curupira*.

No specimens of this genus have actually been observed sucking blood, and its inclusion among blood-sucking Diptera is due to the statement by Fritz Müller that a certain number of the females of the only species at present known, *Curupira* (*Paltostoma*) *torrentium*, F. Müll., have mouth-parts of the blood-sucking type, while other females agree with the males in possessing mouth-parts adapted for feeding upon the nectar of flowers. Müller's conclusion that the two kinds of female both belong to the same species, which therefore presents a striking instance of dimorphism in the female sex, requires confirmation, and it may even be found ultimately that the supposed blood-sucking females merely prey upon other

* Dr. Cuthbert Christy, "Reports of the Sleeping Sickness Commission," No. III., pp. 39-40 (London: Harrison & Sons, November, 1903).

insects and do not feed upon mammalian blood. *Curupira torrentium* occurs in Brazil.

Appearance.—Gnat-like flies, varying from about 4 to 7 mm. in length, with strongly iridescent wings, which are marked with a secondary network of crease-like lines in addition to the veins.

Life-history.—The larvæ are curious wood-louse-like creatures, living in swiftly flowing streams and torrents, in which they attach themselves to bare rocks and stones by means of a row of median ventral suckers. The ordinary segmentation is not visible, but the sides of the body are scalloped out into a series of prominent lobes. The pupa, which bears a pair of respiratory horns in front, is strongly convex above and flattened beneath ; it is found with the larvæ, so firmly attached to the rocks, apparently by means of a chitinous exudation from the under side, that it is not easy to remove it uninjured.

Habits of the perfect insects.—At present unknown. In all probability the males, like those of European species belonging to this family, dance in swarms in the air over the streams in which the preliminary stages are passed.

Simuliidæ (in India known as *Sand-flies*, *Pipsa*, or *Potû flies ;* in British Columbia as *Brûlots*, by the French Canadian trappers ; in the United States as *Black flies*, *Buffalo-gnats*, and *Turkey-gnats*).

This family consists of the single genus *Simulium*, which is universally distributed, and of which about one hundred and fifty species, difficult to distinguish one from another, have been described up to the present time. The females of some of these flies, which are among the most dreaded of all blood-sucking Diptera, sometimes occur in enormous swarms, and by their attacks upon horses, mules, and cattle, especially in certain parts of the United States, occasion great losses among these animals, besides frequently molesting human beings. In the district of South Hungary called the Banat the Columbacz Midge (*Simulium columbaczense*, Schönb.) has been notorious for more than a hundred years, owing to the destruction caused by it among cattle.

Among the foot-hills of the Himalayas in North Lakhimpur, Assam, where the flies are locally called "Dam Dims," the poisonous bites of *Simulium indicum*, Becher, are troublesome to tea-coolies, and in the Western Himalayas during the hot season "Potû" flies are a well-known scourge; it is stated that when the Chakrata-Saharanpur road was under construction numbers of the coolies employed on the work died from the effects of their bites.

Appearance.—Small flies, generally black or greyish, varying in length from $1\frac{1}{2}$ to 4 mm. according to the species, with a con-

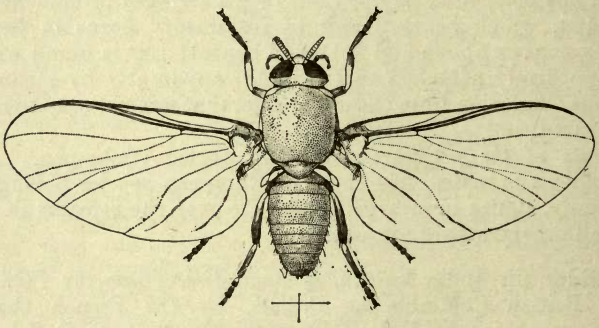

FIG. 45.—*Simulium venustum*, Say (= *reptans*, L.), ♀. N. America. (× 12.)

spicuously humped thorax, short straight antennæ, delicate iridescent wings, stout legs, and with the proboscis not projecting. In the male the eyes appear to occupy the whole of the head, and meet in the middle line above; in the female they are smaller and separate.

Life-history.—The preliminary stages are passed in running water. The eggs are deposited in a compact layer or gelatinous mass on stones or plants close to the water's edge. The larval stage lasts for about four weeks in the summer in temperate climates, though longer in cold weather, and the winter is passed

in this state. According to Johannsen, the full-grown larva of even the largest American species does not exceed 15 mm. in length. In shape the larva is somewhat cylindrical, though broader posteriorly, where it is attached by means of a sucker to a stone, the stem of a water-plant, a dead leaf, or other object. The larva is able to shift its position by crawling in a looping fashion, but usually remains in a more or less erect attitude. It feeds on algæ, diatoms, and parts of phanerogamous plants, which are brought to the mouth by means of the currents set up by two broad fan-like organs situated upon the head. In colour the larva varies according to the species and perhaps also to some extent in accordance with its food, from deep shining black to yellow or dark green. When mature, the larva spins a silken cocoon, within which it pupates and in which the pupa remains motionless, breathing by means of a pair of branched respiratory filaments, which project from behind the head. About a week is occupied in the pupal stage, and then the perfect insect, making its escape through a rent in the back of the thorax, ascends to the surface in a bubble of air, and makes its way to some support on which it rests until its tissues are sufficiently hardened to enable it to fly.

Habits of the perfect insects.—The males, which are incapable of sucking blood, are fond of dancing in the sun in swarms at some height in the air; the females usually remain at a lower level. In attacking horses and cattle they show a great fondness for the inside of the ears; but they also devote themselves to any part of the body where the skin is thin and not well protected by hair; in the case of human beings they frequently attack the corners of the eyes. In Uganda, according to Dr. Christy,* a species of *Simulium* occurs in a "belt" about 12 or 15 miles in length, by 3 or 4 miles in width, on the right bank of the Nile. "In this area the flies swarm at certain seasons in millions," and become such a pest that the natives are forced to leave their plantations. "The bite of this small fly," adds Dr. Christy, "is a very severe one, and causes a wheal which itches intolerably, and is marked by a large drop of blood."

* *Loc. cit.*, p. 40.

Psychodidæ, genus *Phlebotomus* (in Malta, the Sudan, India and Ceylon called *Sand-flies*).

In this family the blood-sucking habit is altogether exceptional, being almost exclusively confined to the genus *Phlebotomus*,* which is represented in most parts of the world, and of which some twenty species are at present known. The females, which alone feed on blood, are troublesome and voracious nocturnal pests, and disseminate a non-fatal human disease known as Sand-fly Fever.

Appearance.—Pale yellowish or brownish-yellow, midge-like flies from $1\frac{1}{3}$ to 2 mm. in length, with the body and wings densely clothed with long hair. Antennæ, palpi, and legs long, eyes large, black and prominent; proboscis straight and rather thick, projecting vertically beneath the head. Abdomen of the female roseate when full of blood. When at rest, these insects stand lightly on the tips of their legs, with wings diverging, and sloping upwards and outwards; if disturbed, they seldom take wing at once, but move in short, spasmodic hops or jumps, generally from side to side. Care must be taken not to confuse with *Phlebotomus*, the harmless species belonging to other genera of Psychodidæ, all of which are small, densely hairy, moth-like flies, but the legs in their case are not long and slender, and the proboscis is scarcely, if at all, visible.

Life-history.—The preliminary stages, are passed in dark and damp places, such as damp earth, piles of brick or other building materials, cellars, and cavities and crannies in old stone walls. The larvæ are cylindrical, with chitinous heads, and can easily be recognised owing to the presence of two or four long bristles at the hinder end of the body. They are very slow in their movements. The wrinkled and brownish last larval skin serves as a means of attachment for the pupa.

Habits of the perfect insects.—According to Rondani, in Northern

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* In England blood has been observed in the abdomen of *Sycorax silacea*, Hal., by the Rev. A. E. Eaton, who also made a similar observation in Algeria in the case of an undescribed species of the same genus. In North Queensland, according to F. H. Taylor, a species of the genus *Pericoma* —tiny, moth-like flies, formerly regarded as completely harmless—is a "very severe biter."

Italy *Phlebotomus papatasii* is found on the higher slopes of the hills as well as in the marshy plains. As evening approaches, the males very often, the females more rarely, are found on windows. *Phlebotomus minutus* appears to be more confined to the low ground near streams, and to enter houses less frequently. Writing of *Phlebotomus papatasii* as met with in Sevastopol, Mr. Robert Erskine, H.B.M. Vice-Consul, states that it "is common in summer, and is found all over the town, principally in rooms," and that "its bite is very painful, especially to newcomers." In Ceylon, according to Mr. E. E. Green, a species of *Phlebotomus* is sometimes more troublesome even than mosquitoes. Though generally supposed to be solely nocturnal, *Phlebotomus* occasionally bites by day; at night it is attracted by artificial light, and a characteristic habit of the insect is to settle noiselessly and suddenly upon the page of an open book or paper, when one is reading by lamplight.

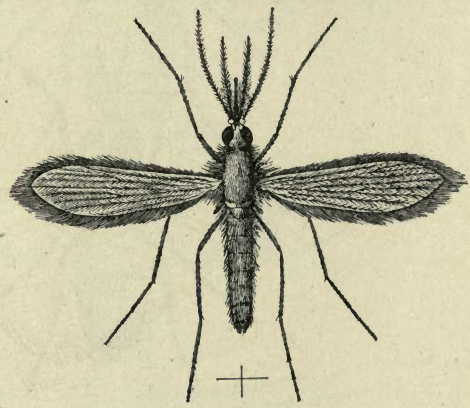

FIG. 46.—*Phlebotomus sp.*, ♀. Kassala, Sudan. (× 12.)

Tabanidæ (*Horse-flies* or *Breeze-flies:* in Great Britain certain species are also known as *Dun-flies*, *Clegs*, and *Stouts*; sometimes called *Gad-flies*: on the Upper Nile termed *Serut-flies*, and in West Africa *Mangrove-flies* — a designation, however, which also includes Tsetse-flies).

As already stated, the enormous majority of blood-sucking Diptera belong to this family, in which the blood-sucking habit is

(with the possible exception of certain species of *Pangonia*) practically universal in the female sex. The Tabanidæ are world-wide in their distribution, and this is among the largest of all Dipterous families, the total number of species at present described amounting to more than 2,000. The majority of the species that have hitherto attracted attention by reason of their bloodthirsty habits belong to one or other of the four principal genera, *Tabanus*, *Hæmatopota*, *Pangonia* and *Chrysops*. Of these the genus *Tabanus*, which includes about 1,000 described species, is abundantly represented in most

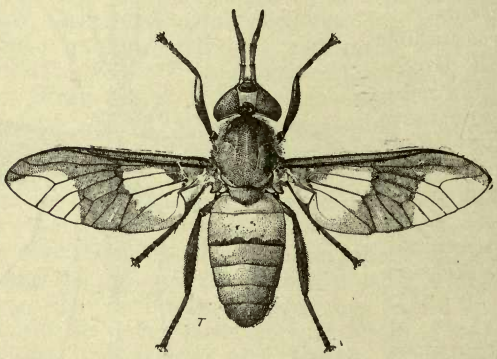

FIG. 47.—*Chrysops fixissima*, Walker, ♀. Singapore, Borneo. (× 3.)

parts of the world; the head-quarters of the genus *Hæmatopota* are centred in Tropical Africa.

Appearance.—Bulky-bodied or smaller flies, ranging in length from about 6 mm. in the case of a small species of *Chrysops* (fig. 47), to more than an inch in that of the largest species of *Tabanus* (fig. 48). The head is large, convex in front, concave or flattened behind, in the male almost wholly composed of the eyes, which meet together above in that sex, but are separated in the female. In life the eyes usually exhibit golden-green or purple markings. The antennæ project conspicuously in front of the

head, as does also the proboscis in many species of *Pangonia* (fig. 49), in which genus the latter organ is sometimes enormously

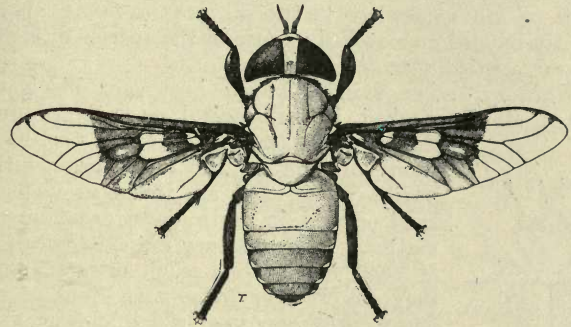

FIG. 48.—*Tabanus africanus*, Gray, ♀. Bahr-el-Ghazal to Natal. (× 2.)

FIG. 49.—*Pangonia magrettii*, Bezzi, ♀. East Africa. (× 2.)

elongated. In other genera the proboscis is short, and protrudes vertically beneath the head, with the piercing mouth-parts enclosed in a fleshy lower lip. In coloration the majority of Tabanidæ are

somewhat sombre, some shade of brown or black being the most frequent hue, the abdomen, however, often being lighter or exhibiting lighter markings. The wings, which, when at rest, diverge at the tips or are somewhat tectiform, are in many species conspicuously banded or blotched; those of the species of *Hæmatopota* are characteristically mottled.

Life-history.—The spindle-shaped brown or black eggs are deposited closely packed in sub-conical or flattened masses or sheets, which are attached to the leaves and stems of plants. The larvæ are whitish soft-bodied grubs, and are found in water, in wet sand or mud, in earth, or in decaying vegetable matter. In shape they are cylindrical, tapering at each end, with a small retractile head, and they are often encircled with rings of retractile fleshy protuberances, which, however, may be confined to the ventral side. These larvæ are carnivorous, preying upon beetle larvæ, snails, worms, etc. The pupa, which is not unlike that of a Lepidopterous insect, remains stationary in the earth or water, or in damp rubbish at the edge of the latter.

FIG. 50.—*Hæmatopota sp.*, from Zululand, in resting attitude, showing the position of the wings (× 2). The wing markings are omitted.

Habits of the perfect insects.—The males haunt flowers of herbage but occasionally hover in the air. The blood-sucking females are persistent tormentors of human beings and domestic animals; horses, cattle, and elephants often streaming with blood in consequence of their attacks. In "The Nile Tributaries of Abyssinia" * the late Sir Samuel Baker speaks of herds of game between the Setit and Atbara Rivers retreating before the attacks of Serut-flies. The species of *Hæmatopota* and *Chrysops*, and the smaller species of *Tabanus* are remarkable for the quietness with which they alight on their victims, the sharp prick of the bite being often the first intimation of the presence of the fly. The larger species of *Tabanus* betray their approach by their loud hum.

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* London: Macmillan & Co., 1867, p. 210.

Leptidæ (no English names known).

The Leptidæ are a small but widely distributed family of slenderly-built flies of moderate size. Their inclusion among blood-sucking forms is due to individuals of four or five different species having been observed in a small number of instances to suck human blood; but since the Leptidæ normally prey upon other insects the blood-sucking habit is certainly exceptional and perhaps to be ascribed to individual aberration. The species in the case of which the habit has been recorded are a member of the genus *Symphoromyia*, the female of which, according to the late Baron Osten Sacken, who observed it near Webber Lake, California, in the month of July, bites quite painfully "and draws blood like a *Tabanus*"; the common European *Leptis scolopacea*, Linn. (of which both sexes have been stated to bite) and *L. strigosa*, Mg.; and *Trichopalpus obscurus*, Phil., a species with an elongated proboscis, common in the Province of Valdivia, Chile, in December and January, and said to be a greedy blood-sucker. The observations with regard to the two species of *Leptis* were made in France.

Appearance.—Narrow-bodied flies, from 6 mm. to 13 mm. in length, with long legs and with the abdomen usually tapering towards the tip. The eyes meet together in the males above the small antennæ, but are separate in the females. The proboscis is usually short and fleshy, occasionally elongate; the venation of the wings resembles that of the Tabanidæ. As a rule some shade of brown or yellowish brown forms the prevailing colour, and the wings are frequently blotched with brown. When at rest the wings are carried flat, or nearly so, diverging widely at the tips.

Life-history.—The oviposition of the alleged blood-sucking species has not been observed. According to Beling, the larvæ of *Leptis*, which are shining white or yellowish in colour, with a small brown head, and four papillæ arranged in the form of a square on the anal segment, subsist chiefly upon earthy and decaying vegetable matter, and are found for the most part in woods, beneath the carpet of leaves or pine-needles, as well as in decaying tree-stumps, etc. The same author states that the larvæ of *Leptis* may be distinguished at the first glance from other

similar larvæ, such as those of *Hæmatopota*, by certain characteristic markings on the upper side of the first two body segments by the structure of the anal segment, and especially by their great mobility. The larva of *Symphoromyia crassicornis*, Pz., a European species, was found by Beling under turf at the edge of a beech-wood. It is described as measuring 12 mm. in length, dirty white in colour, tapering somewhat towards both extremities, with a small brown head.

Habits of the perfect insects.—The flies of the sub-family *Leptinæ*, which includes the genera *Leptis* and *Symphoromyia*, are somewhat sluggish, and are fond of resting motionless and head downwards upon the trunks of trees in shady places. Their flight is short and noiseless.

Muscidæ (*Tsetse-flies*, and their allies).

In this family the blood-sucking habit is highly exceptional, and is confined to certain genera and species, all of which in appearance present a general resemblance to the Common House-fly. In cases in which the blood-sucking habit occurs, it is common to both sexes. The following are some of the blood-sucking genera of Muscidæ hitherto described: *Stomoxys* (with about twenty species; this genus is universally distributed, and it is probable that several additional species have yet to be described); *Lyperosia* (with some nine species, representatives of which are found in most parts of the world); *Hæmatobia* (with five species, two European, two found in India and another in Java); *Stygeromyia* (with three species, found in Tropical Africa and, in one case, in S. Arabia); and *Glossina*, or Tsetse-flies (sixteen or seventeen species, restricted to Africa and Southern Arabia). The genus *Philæmatomyia* (with three or four species, one of which has a very wide range, being found from West Africa and the Mediterranean Sub-Region to the Philippines, while the others occur in India) forms a remarkable connecting link between blood-sucking Muscidæ armed with a piercing proboscis and those species which, though

FIG. 51. *Stomoxys sp.*, from Natal, in resting attitude, showing the position of the wings (× 1⅓).

they suck up blood oozing from wounds caused by biting flies, are themselves incapable of piercing the skin of vertebrates, since in them the proboscis is of the normal type.

Appearance.—As stated above, the blood-sucking Muscidæ all present a general resemblance to the Common House-fly, which however, in the case of Tsetse-flies is obscured by the fact that the wings in the resting position (fig. 53), instead of diverging at an angle, are closed one over the other like the blades of a pair of scissors. With the exception of the largest species of *Glossina*, these flies are all of small or moderate size ; and even the largest Tsetse-flies do not exceed 13·5 mm. (about half an inch) in length, exclusive of proboscis and closed wings. The length of an average specimen of *Lyperosia* is from 3 to 4 mm., that of a similar specimen of *Stomoxys* about 6·5 mm. The coloration of the flies of this group is some shade of grey, brown or yellowish brown, sometimes with darker markings ; in certain of the species of Tsetse-flies, although not in all, the abdomen in conspicuously banded. The wings of blood-sucking Muscidæ are uniformly hyaline or brownish, never blotched or mottled. The sexes are usually very similar, but can generally be distinguished by the eyes being closer together in the males. Lastly, it is to be noted that in nearly all cases there is a hard chitinous proboscis, ensheathed in the palpi in the case of Tsetse-flies, which in its normal position, when not in use, projects horizontally beneath and in front of the head.

Life-history.—With the exception of *Glossina* the species of this group breed, as a rule, in dung, depositing eggs from which are developed white maggots of the type of those of the Common European Blow-fly. According to Riley and Howard, *Lyperosia irritans*, L. (*Hæmatobia serrata*, Rob.-Desv.) oviposits on fresh cow-dung, and its eggs are irregularly oval in shape, flattened on one side, and from 1·25 to 1·37 mm. in length, by 0·34 to 0·41 mm. in width. The newly hatched larvæ descend into the dung, and eventually, when full-grown, attain a length of 7 mm. Pupation takes place in the ground beneath, at a depth of from half to three-quarters

FIG. 52.—*Lyperosia sp.* ♂. Tropical Africa, India and Ceylon (× 3).

of an inch. The puparium is of the normal Muscid type, dark brown in colour, barrel-shaped, and from 4 to 4·5 mm. in length, by 2 to 2·5 mm. in width. *Stomoxys calcitrans*, L., a species that is abundant throughout Europe, Africa, and North America, usually breeds in damp straw, cut and fermenting grass, or in horse-droppings, and its larvæ are very similar to those of the Common House-fly, which also breeds in horse-dung. The life-history of Tsetse-flies is of an abnormal type, the female producing a single larva at a time, which is retained and nourished within the oviduct of the mother until full-grown, and on being extruded at once crawls away and buries itself in the earth, where it turns into a pupa so soon as it finds a suitable hiding-place. The pupa is dark brown, with a pair of prominent granular protuberances at the posterior extremity.

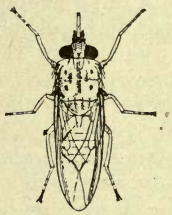

FIG. 53. — *Glossina longipennis*, Corti (East Africa), in resting attitude, showing the position of the wings (× 1½).

Habits of the perfect insects.—Some of the species of this group, especially those of *Stomoxys* and *Glossina*, attack man as well as domestic animals, and it is probable that in the case of *Glossina palpalis*, in certain parts of Central and West Africa, at any rate, human blood forms the chief food; other species of Tsetse-flies appear to subsist normally on the blood of wild mammals or birds.* The species of *Lyperosia* attack horses, cattle, and camels. In the United States *Lyperosia irritans* (*Hæmatobia serrata*) is known as the "Horn-fly" from its habit of clustering in masses about the base and on the concave side of the horns of cattle. According to Riley and Howard, it reduces the condition of stock to a considerable extent, but statements as to the death of animals from its attacks are unsubstantiated. When feeding, the fly is found on the back, flanks, legs, and under the thighs. In Europe and North America *Stomoxys calcitrans* is often found in houses.

* For further information on the habits, etc., of Tsetse-flies, *see* "A Handbook of the Tsetse-flies," by E. E. Austen (London, 1911: published by the Trustees of the British Museum).

A Blood-sucking Larva.—The so-called "Floor Maggot" is the larva of *Auchmeromyia luteola*, Fabr., an African Muscoid fly, which is found from West Africa to Natal, and is itself incapable of sucking blood. The maggot, which attains a length of 15 mm., lives in the floors of native huts, and at night fastens upon the limbs of sleepers and sucks its fill of blood. The perfect insect is about 11 mm. in length, and pale yellow in colour, with the distal portion of the abdomen, except the tip, bluish black.

Hippoboscidæ.

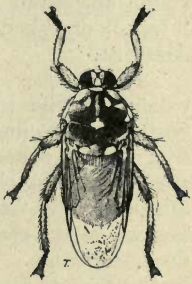

FIG. 54. — *Hippobosca rufipes*, v. Olfers, S. Africa (× 2).

This family, which is distributed throughout the world, includes a number of small genera, the species of which are all parasitic on mammals and birds. From the point of view of possible dissemination of human disease, however, it is unnecessary to consider here the bird-parasites belonging to the genera *Olfersia*, *Ornithomyia*, etc.* The mammal-parasites are comprised in the genera *Hippobosca*, *Allobosca*, *Ortholfersia*, *Lipoptena*, *Echestypus* and *Melophagus*. The genus *Hippobosca* is probably represented throughout the world, and, with one exception,† the twelve species of which it consists are parasitic on horses, donkeys, camels, cattle, antelopes, or dogs. It is probable that certain species have been introduced with horses into new localities. At Pretoria Dr. Theiler succeeded experimentally in inoculating cattle with *Trypanosoma theileri* by means of *Hippobosca rufipes*, v. Olfers (fig. 54). *Allobosca*, comprising the single species *A. crassipes*, Speiser, has only

* Similarly, the bat-parasites belonging to the families Nycteribiidæ and Streblidæ, which with the Braulidæ (bee-parasites) and the Hippoboscidæ make up the group of Diptera known as the Pupipara, may also be disregarded. It should be noted, however, that under exceptional circumstances human beings may be attacked by parasitic blood-sucking insects which are normally found on quite other hosts.

† *Hippobosca struthionis*, Janson, which is found on ostriches in Cape Colony.

rudimentary wings, and is parasitic upon lemurs in Madagascar. *Ortholfersia*, of which two species have been described, is found on kangaroos and wallabies in Australia, Tasmania and New Zealand. The seven or eight known species of *Lipoptena* are deer- and goat-parasites occurring in Europe, North, Central, and South America, Japan, Malacca, Ceylon, Sinai, the Anglo-Egyptian Sudan, and South Africa. Some years ago the European *Lipoptena cervi*, L., was met with in the Transvaal, and it is possible that it was accidentally introduced with remounts during the Boer War. The single species of *Melophagus* (*M. ovinus*, L., the so-called sheep "tick" or "ked") is a parasite of sheep in Europe and North America.

Appearance.—Broad, flat-bodied, horny flies, with long wings, except in the case of *Allobosca*, and of *Melophagus*, which is entirely apterous, and very dissimilar in appearance to an ordinary fly; in the other forms the wings in the resting position lie flat over the body, closed one over the other like the blades of a pair of scissors (fig. 54). The female *Lipoptena* almost invariably sheds her wings on reaching a suitable host, and the male frequently does the same. In length these insects range from about 3 mm. in the case of a small *Lipoptena*, to 12 mm. or nearly half an inch in that of a female *Hippobosca camelina*. The general coloration is a reddish or yellowish-brown, with the thorax mottled with yellow in the case of *Hippobosca*. The legs in all species are powerfully developed, and the claws have a secondary process on the under side to assist the insect in clinging to the hair of the host. The eyes are widely separated in both sexes, and the proboscis consists of a slender tube, which can be protruded from the head between a pair of prominent, downwardly projecting, chitinous blades (the maxillary palpi).

Life-history.—The mode of reproduction of these flies may be described as a further development of the process seen in the Tsetse-flies. In the case of the genera now under consideration, the larva is retained within the oviduct of the mother, as in *Glossina*, but on extrusion it is incapable of movement, shows little or no trace of segmentation, and its integument simply becomes chitinised and darkened to form the pupal envelope. The larva of *Hippobosca*

on extrusion is a white ovoid or globular body, with a black cap at one pole, which speedily becomes almost obliterated by the general chitinisation of the integument.

Habits of the perfect insects.—The winged members of this group as a rule fly but little, and only for the purpose of moving from one host to another, or from one part of the body of a host to another on being disturbed. When using its legs, *Hippobosca* often runs sideways like a crab. The species of this genus found on horses and cattle live chiefly between the thighs, along the perinæum, and under the tail. In India *Hippobosca capensis*, v. Olf. (*H. canina*, Rond.), which infests dogs, has been found to the number of fifty or a hundred on the necks and chests of pariahs.

COLLECTING AND PRESERVING BLOOD-SUCKING FLIES AND THEIR LARVÆ.

Blood-sucking Flies, other than Mosquitoes, and their larvæ should be collected and subsequently treated in precisely the same manner as Diptera which do not suck blood. For all details as to requisites and methods, the reader is referred to pp. 79–97.

Notes on Habits, etc.

Comparatively little is yet known as to the bionomics of Blood-sucking Diptera in general, so that notes on the habits, distribution, seasonal occurrence, relative frequency, breeding places, etc., of particular species will always be of great value and interest. Clinical observations as to the effect of the bites of the various species on man and domestic animals are also required.

Arachnida, Myriopoda, and Peripatus.

I.—Introductory Remarks.

It is necessary to impress upon collectors the importance of securing, if possible, a considerable number of examples of each species. Only by this means can the sexual, individual, and age variations be ascertained; and since animals which seem to be identical at first sight often prove to be quite distinct when critically examined, the preservation of large numbers, even from the same locality, lessens the likelihood of new species being overlooked. Moreover, since species that are exceptionally common are only too frequently neglected because their profusion, which after all may be local or temporary, suggests the probability of their abundant representation in museums, it must be emphatically stated that, with the principal exception of a few forms living in human houses, hardly any species is so well known as to be unacceptable at the British Museum.

II.—Arachnida and Myriopoda:

Habitat.—Millipedes are practically confined to damp localities. They may be found under logs of wood, stones, or decaying leaves, and frequently climbing bushes and trees, especially after heavy rains.

Scorpions, Spiders, and Centipedes are mostly nocturnal, and may be met with in both moist and dry situations, under stones, loose bark, felled tree-trunks, in burrows—in fact, in any suitable spot that affords shelter from the heat and light of day. Some spiders are diurnal and may be caught while darting about in the hot sun. Many Scorpions and large Spiders live in deep burrows,

from which they have to be dug out. Harvestmen, Mites and other small Arachnids should also be looked for. Some of the minute forms found in tropical and warmer temperate countries are of considerable interest, especially those occurring under stones in limestone caverns.

The Trapdoor Spiders close the mouth of their burrow with a movable lid, and are hard to detect. They frequently betray their presence, however, to the collector by rapidly closing the lid at the sound of a footfall. Both the Spider and its trapdoor nest should be procured if possible. Some species of this group in South Africa, Madagascar, South America, and other parts of the tropics make their homes, not in the ground, but upon the trunks of trees. They should be carefully looked for. Many of the smaller species of Solpugas live in Termites' nests and feed upon the occupants.

Small Spiders may be obtained in abundance by beating or shaking bushes and flowers over a sheet of paper or of white linen.

Most of the web-spinning species live on trees or bushes, and, if in the centre of the web, will usually drop at a touch into a wide-necked jar held beneath. If the web is apparently unoccupied, search for the owner should be made beneath the leaves of an adjoining bush, the hiding-place being often betrayed by a silk thread running from the web to the place of concealment.

Rolled leaves frequently contain Spiders and their cocoons. Leaf, Spider, and cocoon should all be preserved if possible. Sketches of webs, or notes as to their structure, are interesting and useful.

Both Spiders and Centipedes may be sought for beneath stones on the sea-shore, or even in the tidal pools.

Ticks are to be found in grass or under stones, but chiefly as parasites upon living and freshly-killed Vertebrate animals; that is to say, upon all Mammalia, including Bats, and even amphibious species—upon Birds, and upon Snakes, Tortoises, and Lizards. The name of the infested host should be written upon the locality label.

"Red Spiders" and other mites injurious to vegetation, and also the species parasitic on domestic animals, are especially wanted.

Book-Scorpions, diminutive Arachnids resembling Scorpions except for the absence of the tail, live normally in moss or under bark. Certain species, however, are to be found beneath the wing-cases of large Beetles or attached to the legs of Flies. One or two forms are restricted to the shore between tide-marks.

For Pentastomida, a curious group of worm-like parasites, *see* No. 12, p. 191.

Millipedes are perfectly harmless, and may be handled with impunity. Scorpions, Centipedes, and large Spiders, on the contrary, are poisonous and should be treated with caution. They can be safely picked up with forceps. Scorpions may without much risk be seized by the end of the tail, the sting being firmly grasped between the finger and thumb ; and even the largest Spiders, being unable to strike upwards, may be safely seized from above with a handkerchief.

Preservation and Packing.—Scorpions, Spiders, Centipedes, Millipedes, and their allies should, if possible, be preserved in *alcohol.* If alcohol be unobtainable, they may be packed in sawdust saturated with carbolic acid or naphthalene, or pinned in cork-lined boxes or wrapped in folded paper ; but none of these methods yield such satisfactory results as immersion in alcohol in the form of methylated or any other kind of spirit that may be available.

Experiments with *formalin* as a preservative fluid for these animals have hitherto met with failure.

Specimens may be killed by plunging them direct into alcohol or hot water. Drowning in cold water is an admirable but tedious method. If alcohol be used for this purpose, it should be well diluted with water. If undiluted, it is liable to stiffen and harden the muscles and to shrink the softer tissues, so that the limbs cannot subsequently be straightened, and the form of other organs may be destroyed. After lying for twenty-four hours or thereabouts in weak spirit, specimens may be transferred with safety to stronger alcohol.

Specimens collected in the same locality may be indiscriminately mixed in the same jar ; but the smaller and more delicate examples should be placed in separate glass tubes or wrapped in

pieces of paper, so that they may escape the chance of breakage by being shaken up with the larger and harder examples.

It is not advisable to plunge large Scorpions, Spiders, or Millipedes while still alive into a jar of spirit already containing other specimens, which are liable to be damaged by their writhing or snapping movements.

Specimens from different localities must on no account be mixed together, unless a locality-label is affixed to each.

When packing for travel, care must be taken that the bottles or jars be either entirely filled with specimens, or, better still, half or three parts filled with specimens, and the rest of the space at the top with pieces of soft crumpled paper or wool wrapped in paper. By this means risk of damage from shaking during transit is reduced to a minimum. When glass tubes are used, they should be wrapped in paper and plugged with cotton wool.

If glass tubes are not available, an excellent substitute may be made by rolling pieces of stiffish paper into the required size and shape and tying them round with white cotton or string.

In the place of glass jars, which have the disadvantage of being both heavy and breakable, tobacco or other tins with an inlet tight-fitting cover make a satisfactory receptacle for specimens of all kinds. The cover should, if possible, be soldered down to prevent possibility of leakage, or fixed by means of a bladder. Neither sealing-wax nor india-rubber should be used to close a vessel containing alcohol, since they are acted upon by that fluid.

If the duration of transit is likely to be short, specimens may be packed in wool saturated with spirit.

Serviceable forceps for purposes of collecting large specimens may be improvised by nailing two pieces of lath to a block of wood.

III.—Peripatus.

Habitat.—Species of *Peripatus* should be diligently sought for in all tropical and sub-tropical countries. They may be found under stones or fallen tree-trunks or damp decaying leaves in localities sheltered from the sun, but supplied with abundance of moisture.

Preservation.—Great care must be taken in killing specimens

of *Peripatus*. The most satisfactory method is drowning in water. To hasten the process a few drops of ammonia may, if desired, be added to the water. If, while still alive, the animal be plunged direct into alcohol or any other preservative fluid, the body and limbs contract and the tissues shrink, so that the specimen is rendered less valuable for museum or anatomical purposes. During the process of drowning the body becomes fully distended. In this state it may be transferred first to weak and then to stronger alcohol.

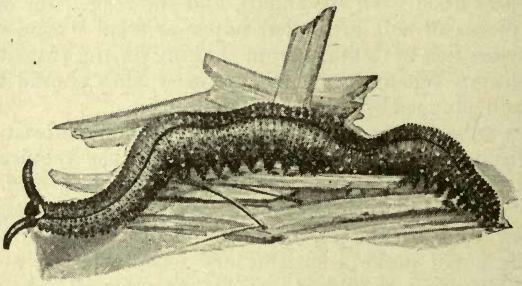

FIG. 55. PERIPATUS BRAZILIENSIS. FROM SANTÁREM.
(Natural size, from life.)

Soft-Bodied and other Invertebrate Animals.

I.—General.

A. Alcohol and Formalin.

Alcohol * is indispensable as a preservative fluid; but certain precautions are necessary in using it. Except in a very few cases, 70 per cent. alcohol is strong enough for preservation. Stronger spirit should not as a rule be used, since it renders the tissues too hard and brittle. Strong alcohol should be reduced, if possible, to the desired strength with distilled water, as ordinary spring-water frequently contains a sufficient amount of carbonate of lime and other substances in solution to give a cloudy precipitate, which may destroy the natural appearance of a specimen.

Formalin or *formol* has been much used of late years in place of alcohol, partly on account of its portability and cheapness. The commercial formalin is a 40 per cent. solution of formaldehyde in water; "5 per cent. solution of formalin" means 5 parts of commercial formalin to 95 parts of water, this strength containing 2 per cent. of formaldehyde.

For marine specimens the commercial formalin may be diluted with sea-water; for fresh-water specimens Mr. H. J. Waddington recommends that a little salt be added to the solution.

As a result of numerous inquiries made among naturalists, it appears that the method now most recommended for preserving invertebrate animals is to place them in a 10 per cent. solution (*i.e.*, 4 per cent. formaldehyde), made by diluting one part of

* *See* No. 13, p. 208.

commercial formalin with nine parts of water. The liquid should be poured away after twenty-four hours ; and fresh solution, usually of only 5 per cent. strength or even less, added.

Formalin is excellent for preserving some specimens ; but caution and further experiment as to its use are necessary. A collector should not entrust all his specimens to this preservative, but should keep some of them in alcohol.

Commercial formalin generally contains a percentage of free acid, and consequently will injure calcified structures, such as molluscan shells, unless the acid has been previously neutralized, as by placing a little chalk or pounded coral in the strong solution.

For further details concerning the use of formalin, see pp. 140–148.

B. Preliminary Preparation.

Before the final preservation of animals in alcohol or formalin certain preliminary measures should, if possible, be carried out. The killing should be effected by means of a reagent which in causing death prevents contraction, and "fixes" the tissues as nearly as possible in the form they had during life. The transference from water to alcohol should be made by gradual stages, the animals being placed first in weak spirit (30 per cent.) and next in stronger spirit (50 per cent.). They are then ready to be transferred to the 70 per cent. spirit in which they are to be stored. With very delicate gelatinous structures, an even more gradual increase in the strength of the alcohol may be desirable. The time during which the specimen should remain in each strength of spirit varies with the size of the animal and with the permeability of its tissues, but in most cases a stay of 1–4 hours should be sufficient.

The killing and fixing reagents most commonly used are chromic acid, osmic acid, and corrosive sublimate ; after employing them, it is necessary to wash the animals in fresh or distilled water before placing them in alcohol or formalin. In some cases formalin can, however, be used with advantage for killing animals as well as for keeping them permanently. In the case of soft contractile organisms it is necessary to narcotize them before attempting to kill them, in order to prevent distortion. Chloral

hydrate dissolved in sea-water or fresh water, in the proportion of 1 to ·1 per cent., is often used for this purpose (*see* also No. 12, pp. 200, 205), while eucaine, cocaine,* magnesium sulphate, menthol, chloretone, weak alcohol and tobacco-smoke are also available. Magnesium sulphate, which is much to be recommended, may be added as required to the water containing the living animals, either as a saturated solution, or in small quantities in the solid form. Alcohol may be used in the proportion of 5 cc. of absolute alcohol to 100 cc. of sea-water, or 70 per cent. alcohol may be carefully poured on the surface of the water. When the specimen no longer shows any tendency to contract, on being touched, it may be transferred to a fixing solution, preferably heated.

Success in preserving fresh-water Polyzoa with their tentacles expanded may be achieved by using eucaine or cocaine.* Mr. C. F. Rousselet recommended adding one drop of a 1 per cent. solution of eucaine or of a 2 per cent. solution of cocaine* to a small vessel of clean water containing the specimen. After waiting ten minutes another drop is added, and again a drop after five minutes, four or five times. The animal is then killed and fixed by adding 10 per cent. formalin (commercial formalin 10 parts, water 90 parts), and is finally preserved in 6 per cent. formalin. This method would probably be useful, with modifications, for animals other than fresh-water Polyzoa.

Corrosive sublimate.—A saturated solution in fresh or sea-water may be used either hot or cold. It acts quickly, and preserves

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* *Use of cocaine in the preservation of animals.*—By recent legislation, the possession of cocaine by unauthorised persons has been made illegal, under heavy penalties, and no person, other than duly registered medical practitioners, registered dentists, registered veterinary surgeons or registered chemists carrying on a retail business in accordance with the Pharmacy Acts, is entitled to purchase or be in possession of the drug, unless he is the holder of a special permit, issued by the Home Secretary. Eucaine is not subject to this restriction, and this substance will probably be found to give results as good as those to be obtained by the use of cocaine, in many if not in most cases. It is accordingly recommended that where cocaine is mentioned as suitable for purposes of narcotization in this number of the "Instructions" (pp. 133, 143, 148 and 152) preliminary experiments with eucaine should be made before applying to the Home Office for permission to purchase or use cocaine.

admirably for histological purposes. It is sometimes desirable to use it mixed with copper sulphate, acetic acid, or chromic acid. Objects hardened in it should subsequently be well washed in distilled water and in iodised alcohol (alcohol, 35 or 70 per cent., 100 cc.; tincture of iodine, 2·5 cc.), to remove all traces of sublimate, which may crystallize out in the tissues of the organisms, and so injure the preparation. Steel instruments should not be brought into contact with solutions of corrosive sublimate.

Chromic acid, 1 per cent.—Objects must not be left in this solution too long, or they become brittle; after immersion they must be washed in distilled water before being put into alcohol.

Glacial acetic acid suddenly kills animals plunged in it (*see* "Tunicata," p. 158).

Osmic acid, 1 per cent. solution, may be used for killing and fixing small gelatinous organisms. Its too prolonged use should be avoided, as it renders them brittle, and causes them to assume a dark brown or black tint. Objects thus treated should be washed in distilled water before being placed in alcohol. Osmic acid vapour is irritating to the eyes and organs of respiration.

Glycerine. (*See* No. 12, p. 202.)

For further information on mixtures for killing, fixing, and hardening used at the Zoological Station at Naples, see :—

Lo Bianco, "Mittheilungen Zoolog. Station Neapel," 1890, Vol. IX., pp. 435–474; abstract of the Italian original in "American Naturalist," 1890, XXIV., pp. 856–865, and in "Journal of Royal Microscopical Society," 1891, p. 133. A verbatim translation into English may be found in Part M of the "Bulletin of the United States National Museum" (Washington), No. 39, 1899; and into French in the "Bulletin Scientifique de la France et de la Belgique," 1891, Vol. XXIII., pp. 100–147.

C. Apparatus for Collecting.

Dissecting instruments, etc. (*See* No. 12, p. 203, under "Apparatus.")

In collecting marine specimens, steel instruments are likely to become extremely rusty by the action of the sea-water. If trouble

is experienced in this respect, it may be avoided by keeping the instruments completely immersed in a jar containing a weak solution of caustic soda or caustic potash. A pair of large wooden forceps will be found useful in handling marine specimens, since trouble from rust can thus be avoided. The instrument can be made by placing two laths of equal length side by side, and fastening (with copper wire or nails) a small block of wood between them, at one end; or by cutting a slot in a narrow piece of wood of suitable strength and elasticity. The slot should not extend the whole length, leaving about 1¼ inches untouched. The piece of wood thus becomes a pair of narrow flexible slips connected by a solid piece at one end.

Bottles, tubes, etc.—Any kind of wide-mouthed bottle can be used for collecting, if properly corked or stoppered. Screw-top fruit-jars will be found specially convenient. If leather rings are employed for these they should be soaked in oil before use. An assortment of corked tubes of various sizes is almost indispensable. Other requisites such as brushes, pipettes, dipping tubes and glass dishes are mentioned on p. 203 of No. 12, under "Apparatus."

Dredge.—A dredge is essentially a bag-like net with the mouth fastened to and kept open by a strong iron frame provided with a pair of "bridles" or arms meeting at a ring to which a wire cable or rope is attached. The rectangular mouth-frame, a convenient size for which is 20 inches by 5, is provided with a series of holes through which is threaded the copper wire or cord used for fixing the net to the frame. The net, which may be 2 feet long, should be protected with flaps of sail-cloth, especially when the dredge is used on rough ground. One arm of the dredge should merely be tied to the ring with string, so that if the dredge should be caught, the string will break under strong pressure and probably release the apparatus from its wedged position.

Trawls, which can only be worked on fairly level ground and with the aid of a vessel larger than a rowing-boat, are very large bag-nets. In the ordinary beam-trawl the mouth is kept open horizontally by means of a long beam and vertically by D-shaped end-pieces. In the Agassiz trawl the beam and end-pieces are arranged so that the mouth of the net remains open whichever

side of the trawl rests on the bottom. The Otter trawl is a form which has special advantages for catching fishes and other animals swimming near the bottom.

Much useful information and several figures of dredges and trawls are given on pp. 289–305 of "Science of the Sea," edited by Dr. G. H. Fowler and issued by the Challenger Society.* Any collector who proposes to do work of this kind would do well to apply to the Museum for advice as to the methods to be employed.

Tangles of unravelled rope may be fixed to the ends of the dredge-net, or may be used by themselves fastened to the links of several short pieces of chain attached to an iron bar. A simpler arrangement can easily be improvised if necessary. Valuable Sponges, Sea-fans, and other organisms may be obtained in good condition if a few fish-hooks have been added to the tangles.

Long lines provided with hooks are often very serviceable, especially on muddy ground in deep water; rare and delicate specimens frequently being captured and brought to the surface in an almost uninjured state.†

Deep-sea animals.—While specimens from great depths are usually obtained by one of the methods just indicated (dredge, trawl, tangles or long lines), they may often be secured during the operations for the repair of submarine telegraph-cables. Those on board cable-ships may be urged to preserve carefully anything brought up from deep water.

Tow-net.—A tow-net is used for surface or pelagic animals. A conical net of cheese-cloth, bolting-cloth, or coarse-woven bunting, several feet in length, is fastened to a ring of flexible cane or other suitable material from 1½ to 3 feet in diameter; it is best to double a strip of cotton cloth round the ring, and sew the net on to the cotton. Three equal lengths of strong fine cord are fastened at equidistant points round the ring, and tied together about 3 to 6 feet in front of the ring. The towing line is attached to the knot, and its length is adjusted so that the net remains in the desired position. A zinc can or bottle is fixed at the bottom of the net,

* London, John Murray, 1912.

† *See* Ijima, Journ. Coll. Sci. Tokyo, I., p. 16, 1901; and "Science of the Sea," Challenger Society, p. 330, 1912.

which is preferably made open, so that the neck of the can or bottle may be tied into it, and removed with the specimens at the end of the operation. If it is required to collect from below the surface, a weight is attached to the line near the knot at the junction of the cords.

When the net is taken on board, the can is emptied, and the net turned inside out into a fish-globe or other vessel full of sea-water. Some specimens may be removed with a pipette for special treatment (*see* p. 142, *Medusæ*). For the rest, osmic acid or formalin is added to the sea-water; the animals will die and sink to the bottom; the sea-water is drawn off, and the residue washed in fresh water and graded (*see* p. 132) into alcohol.

On suitable ground, small Crustacea and other animals which swim on or near the bottom may be caught with the tow-net, to one part of the ring of which a cork should be attached to keep it off the bottom, while a weight on the line a short distance in front of the net keeps it near the ground.

The surface-fauna (plankton) of the sea is often more abundant after nightfall.

In dealing with minute pelagic and other animals, trouble may be saved by placing in a small sieve the specimens to be washed or exposed to the action of reagents. The sieve is made by covering one end of a short cylindrical glass vessel, open at both ends (for instance, a lamp-chimney), with bolting-cloth or other suitable material. The lower end of the sieve, containing the specimens, is immersed in the reagent, and can readily be transferred, without the loss of any of the specimens, to any other fluid.

D. Packing.

1. Any strong, wide-mouthed bottles, with glass stoppers or with sound, well-fitting corks, may be used. Bottles with rubber or leather rings are especially recommended. Use may be made of any sort of tin, carefully soldered; but this is unsuitable for formalin, which corrodes the metal.

2. The specimens placed in one bottle should not be too numerous, and should not occupy more than one-third of the space.

3. The spirit should be quite clean at the time of forwarding.

4. Perhaps the best packing material is horse-hair. Soft paper made into loose balls is fairly good.

5. Many Ophiuroids (dry) travel safely if sewn on to stiff cardboard.

Corals.—Dry specimens of stony corals should be carefully wrapped in several thicknesses of soft paper—as much paper, indeed, as will prevent the angles and points from puncturing it—and should then be laid in sawdust, the coarser the better, and all packed down tightly to prevent jostling together. The object of covering the specimens with plenty of paper is to prevent the filling-material (sawdust and such like) from getting in and choking their calicles and finer sculpturings.

Delicately branching or foliate specimens should be treated in the same way, but in addition should be protected from the weight of the others by being placed in separate boxes, or by partitions nailed into the case.

N.B.—Sawdust or cotton-wool should never come into direct contact with the specimens.

II.—Special.

Protozoa.

Foraminifera.—The dead shells occur in shelly sands, which are sometimes very rich in them. The living organisms are found in the mud or sand of the sea-bottom, or adhering to sea-weeds.

Some species of Foraminifera are pelagic, and live at the surface of the ocean in warm temperate and tropical waters ; these can be collected in the tow-net, or, better, in vessels of sea-water, as several species possess delicate spines liable to be broken in a net.

To separate Foraminifera from sand or mud, when the shells alone are required, Professor W. C. Williamson's method may be adopted. The sand or mud dredged from a few fathoms is dried, and the rougher material separated by a sieve or net. The finer portion is put into a bowl of water, and stirred up. The more

delicate shells with their chambers full of air will float, and can be skimmed off and put into another bowl of water; the water is drawn off with a siphon, and the residue is dried. It is better, before drying the residue, to heat it with caustic potash solution, and again wash in water.

To obtain living Foraminifera, the specimens can be picked off from corallines and other sea-weeds; or the mud and fine sand that come up in the dredge are put into vessels of water, and stirred: the shells, full of protoplasm, will sink.

Mr. J. J. Lister used a horse-hair sieve, with bolting-cloth fastened beneath, to obtain certain shallow-water species. Handfuls of sea-weed are well shaken in a tide-pool over the sieve. The bolting-cloth catches the Foraminifera which pass through the sieve. The specimens are killed in a warm saturated solution of corrosive sublimate; they are then well washed in water, and are finally put into spirit.

Radiolaria.—Many species live at and near the surface, where they sometimes occur in great abundance. They may be captured with a tow-net or in vessels of sea-water.

Some are without a skeleton, and appear like minute oval or spherical lumps of jelly; others are provided with a skeleton of silica or vitreous horny substance.

As a general rule the tow-net is emptied into a glass vessel of sea-water; on adding a few drops of 1 per cent. osmic acid, the Radiolaria die, and sink to the bottom; the sea-water is poured off or siphoned off, the residue washed in fresh water, and treated with weak and later with strong spirit. Simpler methods are to put the animals direct into weak spirit, and later into strong spirit or to use a 2·5 to 5 per cent. solution of formalin.

Freshwater Rhizopods—Dr. E. Penard gives a valuable account of his methods in "Journ. Quekett Micr. Club," Nov., 1907, p. 107.

Porifera (Sponges).

Sponges live in all depths, and occur both in the sea and in fresh waters of rivers, lakes, and ponds; and they vary extremely in colour, form, and consistency.

They often encrust stones, rocks, sea-weeds, etc., or they may be massive or arborescent.

Fresh-water sponges are usually of a brilliant green colour, and may be mistaken for water-plants ; in dark places the green colour is replaced by pale buff. They grow on the piles of bridges and locks, or on the stems or roots of water-plants.

On the banks of the Amazon, specimens are found high and dry on the branches of bushes and trees which have been submerged during the rainy season, the blackish or earthy clumps of sponges often being mistaken for ants' nests. Shallow-water marine sponges are often found in shady places under rocks or in caves.

Notes should be taken of the colour of living sponges.

Specimens growing on pier-piles may be removed with a rake or a Dutch hoe with a bag of bolting-cloth conveniently fixed beneath. Forms living in deeper water are obtained with the dredge.

To preserve sponges, they should be killed as soon as possible by putting them into strong spirit, or into a 10 per cent. solution of formalin. The latter, however, is not recommended, as it appears to act rather as a temporary than as a permanent preservative. A certain amount of chemical change is said to take place in the tissues when formalin is used. Formalin should not be used for calcareous sponges. The preserving medium should be changed after the first twenty-four hours, only 5 per cent. formalin being used later.

When several specimens are put into one bottle, each should be tied up separately in muslin. Large specimens may be preserved dry, by immersing for two hours in fresh water, followed by immersion in ordinary alcohol for one day, and then by exposure to sun and air.

To preserve the delicate calcareous Ascon sponges so as to be available for purposes of research, Professor E. A. Minchin* took on his collecting excursions bottles containing respectively 1 per cent. osmic acid, distilled water, and picrocarmine solution. The sponge was put into a bottle containing equal parts of sea-water

* "Quarterly Journal Microscopical Science," Vol. XL., 1898, p. 474.

and 1 per cent. osmic acid from five to ten minutes. The specimen was then rinsed in fresh or distilled water, and placed in picrocarmine for from one to two hours. Lastly, it was washed in distilled water, and transferred to alcohol.

Coelenterata.

(1) Hydrozoa.

This group includes the delicate branching Hydroids, the Coral-like Hydrocorallines, and the gelatinous Siphonophores and Jellyfishes; and no single method can be recommended for animals so different from one another in character. The collection of the gelatinous forms should not be attempted unless the best methods can be employed.

Hydroida (Sea-firs, etc.).—The more commonly known species form branching tree-like colonies rooted to stones, rocks, etc. Shallow water forms will be found in pools left by the tide; and those from deeper water, often attached to stones or the shells of molluscs and similar objects, are obtained by dredging.

The fresh-water forms *Cordylophora* and *Hydra* occur in rivers, docks, etc., and should be looked for on water-plants.

Hydroids should be preserved in spirit or in 5–7 per cent. formalin, after narcotization and killing by magnesium sulphate (*see* p. 133) or by the following method,* which may also be used for obtaining specimens with expanded polyps:—The living specimens are placed in a tall jar, with just enough sea-water, well aerated by shaking, to cover them. When the polyps are expanded, a hot saturated solution of corrosive sublimate is poured in. In a few minutes the sublimate solution is poured off, and fresh water added, to be followed by weak and then by strong spirit.

Hydrocorallinæ.—This group includes the *Milleporidæ* and

* H. N. Moseley, "Admiralty Manual of Scientific Enquiry," 5th edit., *Zoology*, p. 357.

Stylasteridæ. Any observations on the living polyps would be valuable. It would be of special interest to discover the minute medusiform individuals which, in some species, escape by rupture of the wartlike elevations which stud the surface in certain parts.

Magnesium sulphate or the method of suddenly killing by means of hot corrosive sublimate should be tried for obtaining specimens with expanded polyps.

Siphonophora.—These animals are very difficult to preserve satisfactorily, owing to the tendency of the swimming bells, polyps, and tentacles to break away. The method of killing and fixing with osmic acid, washing in fresh water, and grading into alcohol or formalin, may be adopted (*see* below, *Medusæ*). For other means of preserving, the collector is referred to Lo Bianco's paper* on the Naples methods, or to the cupric sulphate method of Bedot quoted by Mr. A. Bolles Lee.†

Medusæ.—Medusæ or Jellyfishes in many instances represent one phase in a series of transformations undergone by an organism in the course of its life-history.

Many of the smaller forms are budded off from fixed Hydroids. In the case of some of the Scyphomedusæ (*e.g.*, *Aurelia*) the oval free-swimming embryo settles down and becomes a minute white polyp with long tentacles; the polyp divides transversely, so as to resemble a pile of saucers; the latter become free, and ultimately develop into the adult form. It is important to obtain all these stages.

For early stages of Scyphomedusæ (*Scyphistoma*, *Strobila*) Lo Bianco recommended killing with warm corrosive sublimate, washing in fresh water, and grading into spirit.

The discovery of new forms of fresh-water Medusæ would be an event of the greatest interest.

Mr. E. T. Browne‡ has obtained good results in preserving the smaller kinds of Medusæ by using formalin, after killing and fixing

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* References on p. 134.

† "Microtomist's Vade Mecum," 3rd edit., 1893, p. 458.

‡ E. T. Browne, "Proc. Liverpool Biol. Soc.," 1895, IX., p. 245; and "Proc. Zool. Soc.," 1896, p. 461.

with a saturated solution of picric acid. The contents of the tow-net are emptied into a glass vessel of sea-water. By means of a pipette any particular specimen is removed to a watch-glass of sea-water. Five drops of eucaine or hydrochlorate of cocaine* are added, and in a few minutes another five or ten drops. When the Medusa is motionless and has its tentacles extended, any superfluous water is drawn off, and a saturated solution of picric acid is added suddenly; if a precipitate is thrown down, it is removed, and fresh picric acid added, the Medusa being left in it for half an hour, and finally treated with 2·5 per cent., and later 5 per cent. solution of formalin.

Larger Medusæ (*Pelagia*, *Rhizostoma*, etc.) are killed by adding to the sea-water in which they are swimming 3 per cent. of a 1 per cent. solution of osmic acid. As soon as they begin to assume a pale brown tint, they are washed in fresh water for two minutes and put into 35 per cent. alcohol, and later into 70 per cent. alcohol. Mr. E. T. Browne recommends a 10 per cent. solution of formalin for final preservation of most Medusæ.

(2) Ctenophora.

The caution given at the commencement of the part dealing with Hydrozoa (p. 141) applies with even greater force to this group.

Small forms are treated with osmic acid and alcohol, according to the method given above for the large Medusæ. Lo Bianco recommended that they should be killed by allowing them to fall into chrom-osmic acid mixture (100 cc. of 1 per cent. chromic acid and 2 cc. of 1 per cent. osmic acid), and allowed to remain in the mixture for from fifteen to sixty minutes, according to size, and then graded in alcohol up to 70 per cent.

(3) Anthozoa or Actinozoa.

The systematic study of most of the members of this group has hitherto depended mainly on the characters of their hard parts,

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* *See* footnote on p. 133 for particulars of legal restrictions on the use of cocaine.

which are familiarly known as "corals." The majority of the collections of Anthozoa consist principally of dry corals, and it would hardly be possible in practice to keep very large specimens in any other way. Well preserved corals, in which the polyps are thoroughly expanded, are of great value, however, for study; and small specimens, or typical portions of reasonable size taken from large colonies, should be selected for preparation by one of the methods recommended below. The determination of the Sea-anemones, which have no skeleton, is specially difficult unless the animals have been preserved well expanded and by the best methods. It should further be realized that almost all the Alcyonarians (Gorgonians, Pennatulids, etc.) have their soft tissues crowded with microscopic spicules. As these are calcareous and therefore readily dissolve in any kind of acid, a piece of an Alcyonarian colony should be cut off and kept dry, or placed in spirit without having been exposed to the action of an acid, in all cases in which the remainder of the specimen is to be preserved by a method involving the use of any sort of acid. The two parts of the same colony should of course be labelled in such a way as to show that they belong to one another.

The following directions refer to the preparation of such parts of the collection as are not to be sent to the Museum in a dry condition.

The first care must be to place the selected specimens in clean sea-water, to allow them to expand—a result which may not be obtained in some cases for twenty-four hours. It is recommended that narcotization with magnesium sulphate (*see* p. 133) or with menthol should then be tried, and if well-expanded specimens can be obtained in this way, the methods recommended below may not be required. When the animals have been rendered insensitive they may be treated with formalin (if not already dead) and then transferred to alcohol.

Alcyonarians should be killed with chrom-acetic solution,* withdrawing the water in which they lie until there is left just

* Concentrated acetic acid 100 c.c., 1 per cent. chromic acid 10 cc.

enough to cover them, and then adding a volume of the chrom-acetic solution double that of the sea-water. The animals should be removed from this mixture the moment they are killed, since the acid will quickly attack their calcareous spicules, and should be placed in 35 per cent. or 50 per cent. alcohol. It is well to inject the alcohol into the mouths of the polyps in order to keep them fully expanded. The preparation should finally be preserved in 70 per cent. alcohol.

Sea-anemones may be successfully narcotized by magnesium sulphate or menthol. Some species may be killed in a fair condition by pouring over them boiling corrosive sublimate, and then, before putting them in alcohol, treating for a few minutes with 0·5 per cent. chromic acid.

Stony Corals should be allowed to expand fully, and should then be killed with a boiling solution of corrosive sublimate and acetic acid used in volume equal to that of the sea-water containing the coral.* The colony should then be transferred to 35 per cent. alcohol, some of this fluid being injected into the mouth of each polyp. The injection should be repeated at every change of the alcohol, and the specimens should be preserved in 70 per cent. alcohol, after washing them well in iodised alcohol.

Professor Hickson writes, in reference to the Alcyonarian Corals, as follows:—All Stolonifera, including *Tubipora*, preserve well in spirit. *Tubipora* and some of the large *Clavularia*, however, hold in their cavities a large amount of sea-water, and consequently the spirit in the bottle soon becomes weak, and must be changed once or twice.

The only satisfactory way of killing *Tubipora** expanded is to throw a concentrated solution of corrosive sublimate on to a colony when expanded in a shallow pool on the reef; but if expanded colonies are removed as rapidly as possible from their position and plunged into strong spirit, the polyps are killed partially expanded in a manner useful for investigation.

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* In all these cases, preliminary narcotization is desirable, and magnesium sulphate should be tried for the purpose. If successful, the special procedure recommended may not be required.

Thick coriaceous Alcyonarians, like *Alcyonium* or *Sarcophyton*,* are capable of contracting so tightly that spirit and other preservatives fail altogether to penetrate their tissues, unless special care is taken. Nearly all specimens taken from a dredge and placed whole into spirit are almost useless for anatomical investigation. If they can be made to expand in a basin of sea-water, and are then plunged into a mixture of chromic acid and strong acetic acid, or into strong spirit or corrosive sublimate, the structure of the polyps is preserved.

In preserving these forms, however, it is important to bear in mind that, if two or three slices about $\frac{1}{4}$ or $\frac{1}{8}$ inch in thickness are preserved separately, they afford the most valuable material for investigation and study. Five per cent. formalin gives satisfactory results if the polyps can be induced to expand in a basin of sea-water after capture.

Nearly all Gorgonians* have such a dense covering of spicules that preserving fluids cannot penetrate into their tissues. We are consequently almost entirely ignorant of the canal-system of any but the most common species.

When a Gorgonian is captured, therefore, in a dredge, a part of the "bark" should be stripped off and preserved separately in strong spirit, or allowed to remain attached to the axis, if the spirit in which the specimen is preserved can be kept of good strength, *i.e.*, not less than 70 per cent.

The Pennatulids* can be fairly well preserved by immersion whole in spirit; but it is always advisable, if more than one specimen of a species is obtained, to make a long incision into the axis with a knife before plunging into the spirit. Pinnæ which can be snipped off with a pair of scissors and preserved separately yield good material for anatomical study.

Worms.†

For parasitic Worms (Cestodes, Trematodes, and Nemathelminths) *see* No. 12, p. 206.

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* *See* footnote on p. 145.

† *See* the fuller instructions contained in No. 12, Worms, pp. 180–207.

Turbellarians are most satisfactorily killed with corrosive sublimate, either cold or hot. *Sagitta* succeeds best in copper sulphate and corrosive sublimate or chrom-osmic mixture.

Nemerteans should be narcotized with magnesium sulphate (*see* p. 133) or in a 1 per cent. solution of chloral hydrate in sea-water, where they should remain for from six to twelve hours. They are then to be hardened in alcohol or formalin. Gephyreans may be narcotized with 1 per cent. solution of chloral hydrate in sea-water, or in alcoholized sea-water, from three to six hours; or may be killed at once in 0·5 per cent. chromic acid: this last method may also be applied to *Hirudinea*. Chætopods are best narcotized in sea-water containing 5 per cent. of absolute alcohol, or by adding gradually to the surface of the sea-water in which they are contained a mixture of glycerine 1 part, 70 per cent. alcohol 2 parts, and sea-water 2 parts, hardening them subsequently in alcohol. The *Hermellidæ*, *Aphroditidæ*, and *Eunicidæ* may be killed in cold corrosive sublimate. Some of these, such as *Diopatra*, should, however, be narcotized in alcoholized sea-water.

Serpulidæ, before treatment with corrosive sublimate, should be narcotized in 1 per cent. chloral hydrate, which causes them to protrude wholly or partly from their tubes.

Rotifera.*

It is not worth while to collect these microscopic animals unless the best methods are used. The procedure recommended on p. 133 for fresh-water Polyzoa should be employed, except that a few drops of a 1 per cent. solution of osmic acid should be added to the water, to kill and fix the material, instead of formalin. The osmic acid must then be washed out with water or formalin (6 per cent. solution,) and the specimens kept in 6 per cent. formalin.

It is advisable to kill some of each species without previous narcotization; *i.e.*, in the contracted condition.

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* Valuable instructions for the preparation of these animals are contained in a paper by P. de Beauchamp, published in the "Proc. U.S. Nat. Mus.," Vol. XLII., 1912, pp. 181–185.

Polyzoa.

Polyzoa are horny, calcareous, or gelatinous ; they encrust other objects, or form massive or arborescent growths. They are nearly all colonial animals, and usually the small separate " zooecia " can be made out with the naked eye or with a lens. Polyzoa are mostly marine ; but there are also a number of fresh-water species.

These animals may be preserved in 70 per cent. spirit or in 5 per cent. formalin. The latter is to be recommended for gelatinous species, but should be avoided for calcareous forms, which should if possible be preserved in spirit.

Specimens with polyps expanded can be obtained by narcotization with eucaine, cocaine,* chloral hydrate, or alcohol ; see also p. 133 for Mr. Rousselet's method with eucaine.

Collections of dried *calcareous* Polyzoa are by no means without value. If specimens are to be sent in this condition, it is advisable to wash them with fresh water in order to remove the salts contained in the sea-water. Care should be taken to prevent the specimens from crushing one another, particularly if encrusting species growing on heavy stones are sent. The specimens may be wrapped in tissue paper, but it is important not to bring them into contact with cotton-wool, the fibres of which are difficult to disentangle from the Polyzoa.

Brachiopoda.

Signor Lo Bianco recommended narcotizing in alcoholized sea-water. Before placing in alcohol for final preservation, a small chip of wood is placed between the valves of the shell. Without this precaution sea-water will be retained between the shut valves, and the soft parts will putrefy.

Mollusca.

The group includes :—

Amphineura, ex. *Chiton* (the coat of mail shell) ;

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* *See* footnote on p. 133, for particulars of legal restrictions on the use of cocaine.

GASTROPODA, ex. *Buccinum* (whelk), Pteropoda (Sea-butterflies); slugs, snails,

SCAPHOPODA, ex. *Dentalium* (elephant's tusk shell);

CEPHALOPODA, ex. *Octopus*, *Loligo* (squid);

LAMELLIBRANCHIATA, ex. *Ostraea* (oyster), *Anodonta* (fresh water mussel).

The greatest need at present in this branch of Natural History is for well-preserved, complete specimens of Molluscs, *i.e.*, both soft parts and shell, with the animal well extended. Observations made in the field upon the habits, distribution, colour (before preservation) and other such points are specially needed in addition to the actual specimens.* After capture many molluscs can be turned out in a box or jar of water and kept for some time under observation.

On the other hand, it is sometimes impossible through lack of time or the necessary reagents and preservatives to collect and prepare complete specimens. If the collector can only secure shells it is well to observe that small land-molluscs usually dry up in their shells in captivity, in which condition they can travel satisfactorily without much risk of damage resulting from decay. Large specimens should be removed from their shells, when absolutely necessary, either by immersing them in boiling water or by drowning them, after which they can be pulled out of their shells, care being taken that as little of the soft tissues as possible is left behind.

1. *Marine Molluscs* may be obtained :—(1) By searching on or under rocks and sea-weed at low water, or on coral reefs, on sandy beaches and in shore pools. Lamellibranchs may be found by digging in the sand or mud, on beaches or at river-mouths : their presence is generally indicated by a circular breathing-hole in the sand. They are also found on shingle-beds, while empty shells may be picked up along the shore. (2) By dredging at various depths, a method which must be used for the collection of deep-sea

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* Notes should be written with a good dark pencil (BB) (not an "indelible") upon tough paper, and should be carefully assigned in packing to the relevant specimens.

forms. After a storm shells from tolerably deep water may be found cast up on the shore, and search should always be made as soon as possible after rough weather, as exposure spoils the lustre of such specimens.

Limpets, etc., should be detached by passing a thin blade quickly under the shell, taking care not to break the edges. Small shells on and in sea-weed, and limpets, etc., adhering to stones will drop off and sink to the bottom in a vessel of cold fresh water.

For Cephalopoda and the delicate pelagic Gastropoda (Pteropoda and Heteropoda) dredging and tow-netting are necessary, though Cephalopoda are often found stranded or washed up on the shore. The sea-slugs (Nudibranchiata) may be taken in shore-pools, but they usually require to be dredged up from the bottom on which they live.

2. *Freshwater Molluscs* may be obtained in rivers, lakes, ponds or marshes, as well as in ditches and reservoirs. The Lamellibranchs are usually found on the bottom amongst stones or buried in the mud and sand, among plant-débris or among the roots of aquatic plants. Gastropods are found chiefly on the banks, on reeds and plants near the edge, and on the under surfaces of leaves and on stems of aquatic plants.

3. *Land Molluscs.*—These resemble the garden snail, more or less, in their habits though varying greatly in shape, size, and colour. They mostly abound in chalk or limestone districts, and in moist and wooded situations. Some species inhabit low and damp spots, roots of trees, hollows and crevices of rocks and walls; some lie under stones or pieces of wood, or in the earth; others climb shrubs, and in tropical climates even lofty trees. Their haunts vary according to the weather and the season. They come out early in the morning, and after rain. Some bury themselves in moist places during the dry season, or burrow under leaves, grass, or stones, often closing the mouths of their shells with a white secretion to prevent evaporation during the period of torpidity.

If possible, plant-débris and the accumulation in dry stream-beds should be collected in masses and examined carefully for minute forms.

In collecting shells care should be exercised to select only

those in good condition, *i.e.*, in which the colour and lustre are preserved.

The young forms and eggs of all forms of oviparous molluscs should be collected, as well as the characteristic capsule-clusters deposited by marine forms. For this purpose animals kept under observation, as described above, are especially useful.

With regard to the mode of preserving shells :—

1. No attempt should be made to clean them, or to remove the furry skin, more or less thick, with which they are often covered, beyond removing with a soft brush any adherent mud or sand.

2. Every effort should be made to preserve the animal; but if, through lack of reagents, this is impossible, land and fresh-water Molluscs may be killed by immersing them for a few minutes in *boiling* water, after which the bodies may be extracted whole with any suitable instrument. Hot water should not be used with marine shells, as it often destroys their lustre. They should be buried, if time permits, in sand, or other dry material, until the animal dries up (in small shells) or rots (in large specimens); or they may be drowned in cold fresh water, and hung up in the air to dry or rot away. In the former case, if there is an operculum (with which many species, both marine and land, close their mouths, more or less partially), it will, generally in the case of land-shells, remain in its place, adhering to the shell. If hung up to dry the decayed matter should be washed out, and the operculum, if any, replaced and fixed on cotton-wool filling the shell. This applies equally to land-shells.

3. Care should be taken not to injure the edge or lip of the mouth of univalve shells, or the ligament of the hinge of bivalve shells. When Bivalves gape on dying in water, or if the ligament be broken, the valves should be closed and tied together * after the animal has been extracted. If the ligament of a gaping Bivalve should become dry and stiff, it can be softened by putting it in water.

4. The locality in which each specimen was found should be written on the label and, in the case of a dredging, the depth of water.

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* Black or coloured cotton or string should not be used.

With regard to the mode of packing shells for transport :—

All solid shells may be wrapped in one or two folds of paper of any kind. Fragile and minute shells should be put, generally separately, into a box or bottle—with or without cotton-wool, as required. Such packets may be heaped up in any box, heavy shells at the bottom, without pressure, and any space at the top filled with paper or other elastic material. Sawdust injures the lustre of many species.

Preservation of the soft parts (mainly based upon Lo Bianco's methods).—Nearly all Molluscs require to be narcotized before killing and preserving. For this purpose eucaine or cocaine,* 70 per cent. alcohol, or magnesium sulphate (*see* p. 133) may be used.

For land-forms cotton-wool saturated with eucaine or cocaine* may be put into the vessel containing the animal, or magnesium sulphate may be used. Land-slugs may be drowned in water.

With marine and fresh-water forms, a few drops of the reagent used should be added at intervals to the water they are kept in. Lamellibranchs, Placophorous Amphineura (*Chiton*), and shelled Gastropoda (including Heteropoda) may be treated in this way. To prevent contraction of the two valves of Lamellibranchiata plugs of wood should be inserted between them before placing them in the preservative, while the opercula of Gastropoda should be drawn out as far as possible and tied to the shell.

The best general fixative is Bouin's solution (picro-formol-acetic), in which specimens can be left for a considerable time. They should be transferred from it to 70 per cent. alcohol.

Gymnosomatous Pteropoda should be narcotized with chloral hydrate 1 per cent., and killed with acetic acid or corrosive sublimate. Shelled forms may be killed with alcoholized sea-water or corrosive sublimate. Of the Opisthobranchiata, the Elysiidae and Eolids should be allowed to expand in a small volume of sea-water. A volume of concentrated acetic acid equal to or double the amount of water is then poured over them. Dorids should be narcotized with alcohol, and killed with concentrated acetic acid or boiling

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* *See* footnote on p. 133 for particulars of legal restrictions on the use of cocaine.

sublimate. *Aplysia* may be narcotized with chloral hydrate (a tea-spoonful to a moderate-sized beaker of water), and transferred to 1 per cent. or 2 per cent. chromic acid to harden. They are then washed thoroughly before being placed in alcohol.

Scaphopoda : Dentalium and its allies should be narcotized with chloral hydrate. *Cephalopoda :* If the animal has been picked up on the shore in a wrinkled and distorted condition, it should be soaked in sea-water for about an hour. Large octopods may be narcotized with chloral hydrate, killed in chromic acid 1 per cent., and washed in fresh water. Small octopods are narcotized in chloral hydrate 1 per cent., and placed directly in 70 per cent. alcohol. Decapoda may be killed and fixed in 70 per cent. alcohol. A longitudinal incision should be made in the ventral body-wall to allow the spirit to reach the viscera. *Loligo* may be narcotized and fixed by keeping it in formalin 10 per cent. in sea-water for twenty-four hours. In all these cases narcotization and fixation should be followed by preservation in 70 per cent. alcohol or in formalin.

The following points are to be remembered :—

(1) If corrosive sublimate is used for killing, the specimen should be washed afterwards in iodine (a few drops in 70 per cent. alcohol).

(2) Although formalin has advantages as a colour-preservative, it must ultimately be changed for alcohol.

(3) The preservative should be changed after a day or two. Indeed, to secure the best results it should be changed repeatedly until it is quite clear.

(4) Fixatives containing an acid are destructive to shell-substance. One or two specimens should therefore be selected from material that is to be fixed, and preserved dry or in alcohol.

Crustacea.

Collecting.—Many species may be obtained by collecting between tide-marks. Large and conspicuous shore-crabs are commonly (but not always) well-known and widely distributed species, and

are less likely to be of value for the Museum than the smaller forms which have to be sought for under stones, among weeds, or in the crevices of coral-blocks. On the other hand, species which are used for food are often neglected on the erroneous supposition that they are well-known. Thus the large lobsters or sea-crawfish from the less visited parts of the world are likely to be of interest.

On *sandy beaches* many Crustacea are to be found by digging just above low-water mark. In addition to crabs, the lobster-like Thalassinidea, Stomatopoda, and other large kinds, as well as numbers of minute Amphipoda, Cumacea and other forms inhabit such localities. The best method for collecting these is to stir up a spadeful of the sand in a bucket of water, and, after allowing the coarser sand to settle for a few seconds, to pour off the water through a fine muslin bag. After repeating the operation two or three times, the contents of the bag are washed into a tube or small bottle of spirit, and preserved in mass, the sorting out being left to be done in the Museum.

Dredging is the most effective means of obtaining Crustacea from deeper water. After the conspicuous animals have been picked out from the contents of the dredge, the "rubbish" should be washed in clean sea-water and the washings strained off as described above.

Fishermen should be induced to retain for examination the weeds, zoophytes, etc., brought up from deeper water; and from these many of the smaller Crustacea may be recovered by washing.

Pelagic Crustacea may be collected by the tow-net used as described on page 137, avoiding the use of an unnecessarily fine net. A fine-meshed net may not capture a single specimen of the larger Crustacea, even though these are swarming in the water through which it is drawn.

Parasitic Crustacea should be looked for on fishes, whales and turtles, in bivalve molluscs, Ascidians and sponges, on zoophytes, and even on the larger Crustacea (*see* also No. 12, p. 192). On fishes they are often found under the fins, on the gills, or in the mouth. Whale-lice are found commonly on those parts of the body where the skin is folded or wrinkled, and other parasitic Crustacea even on the "whalebone."

Fresh-water and Terrestrial Crustacea are often of very restricted geographical range, and even the large and common river-crabs and river-prawns are worth collecting in nearly all parts of the world. The small river- and pond-shrimps which may be fished with a hand-net are often of exceptional interest, and no opportunity of collecting them should be lost.

The fresh-water crayfishes (as distinguished from the large river-prawns often mistaken for them) have a remarkable geographical distribution, and it is desirable that the exact range of each species (especially in the Southern Hemisphere) should be more precisely known. Specimens of any species will therefore be welcome.

Collections of water-fleas and their allies may be obtained by fishing in ponds and lakes with a fine muslin ring-net, the mouth of which may be provided with a conical guard of wire gauze when working among weeds; and the captures should be preserved in bulk, to be afterwards sorted in the Museum.

Truly terrestrial Crustacea (as distinguished from the more or less amphibious marine and river forms) are represented by the land-crabs (Gecarcinidæ), land-hermits (*Coenobita*) and coco-nut crabs (*Birgus*). The distribution of these is still imperfectly known; and specimens, especially from out-of-the-way localities, are likely to be of value.

Another group of terrestrial Crustacea is that of the wood-lice (Oniscoidea), which are often mistaken for Myriopods or insects. These should be collected, wherever possible, in the wild country, away from houses or gardens. Many species found in gardens have been introduced, and are of less interest than the native species which they supplant.

Preservation.—Where possible, all Crustacea should be preserved in spirit. Crabs, prawns, and the like, if put alive into strong spirit, may throw off some of their limbs or else become so rigid that these break on the slightest manipulation. This may often be avoided, in the case of marine species, by leaving them to die in fresh water, care being taken not to allow them to remain in it longer than is necessary, as it causes a distortion of the membranous appendages. Undue rigidity is often avoided also by killing the

animals in weak spirit (30 per cent. or less) before preserving in strong spirit.

Formalin is to be avoided for most Crustacea. The larger kinds become stiff and fragile, and small forms, such as Cumacea, may become decalcified. For Crustacea collected by the tow-net, however, formalin gives good results. A few drops of strong formalin added to the water into which the tow-net has been washed kills the animals in a few minutes. After they have sunk to the bottom the liquid may be poured off and replaced by formalin diluted with sea-water (for marine plankton) or by a mixture of formalin and spirit. The use of a small sieve, as described on p. 137, is to be recommended.

Where it is not possible to preserve large crabs and lobsters in spirit they may be dried. The carapace should be detached, and the viscera and flesh cleaned away as far as possible, a bent wire being used if necessary to extract the soft parts from the legs. The specimen should then be dried in the shade, any loose legs tied to the body with string, and the whole carefully packed in shavings or sawdust.

Finally, the collector may be reminded that in the less frequented parts of the world *everything*, no matter how common or how obscure, should be collected; also, that bad specimens may be be better than none at all. Opportunities for collecting should never be wasted merely because all the conveniences for careful treatment of the specimens are not at hand. Many interesting Crustacea have reached the Museum in fairly good condition in rum or native spirit. If spirit cannot be procured, formalin should be used; and in the last resort the specimens, if not very small and soft, should be dried.

Pycnogonida.

These are animals of a somewhat spider-like appearance, usually with a narrow body and four or five pairs of long and very slender legs. They are found mostly on Hydroids, among the branches of which they are often difficult to detect, or on Sea-anemones, but occasionally on Jellyfish. The methods of preservation used for Crustacea are suitable for these animals.

Echinoderma.

Starfish may be prepared with the ambulacral feet in full distension by allowing them to die in from 20 to 30 per cent. alcohol. Echinoids (Sea-urchins) should be placed in a small quantity of water, and killed with chrom-acetic mixture (*see* p. 143), being removed from it as quickly as possible, as the acid corrodes the test. To preserve the internal parts, it is necessary to make two opposite openings in the test, so that the alcohol may penetrate the interior readily.

Holothurians, such as *Thyone* and *Cucumaria*, after the tentacles are fully expanded, should be seized a little below the bases of the tentacles by forceps, using a slight pressure, and the anterior portion of the body should then be immersed in concentrated acetic acid. Alcohol (90 per cent.) should then be injected into the mouth, and the specimens placed in 70 per cent. alcohol. The injection should be repeated each time the alcohol is changed. This method is used for killing the animals with their tentacles expanded. But as acids dissolve calcareous spicules (which are abundant in the skin of most Holothurians), other specimens should be preserved in alcohol without the use of any kind of acid.

Synapta should be fixed by immersion in a tube containing a mixture of sea-water and ether (or chloroform), where they remain completely expanded. They should then be washed for a short time in fresh water, and passed into alcohol, taking care to increase the strength of this very gradually.

Tunicata.

The minute tailed Ascidians, known as Appendiculariæ, usually occur in abundance at the surface of the sea. Signor Lo Bianco recommended killing them in a mixture of chrom-osmic acid (*see* "Ctenophora," p. 143), and leaving them in it for five minutes; they are then washed and placed in alcohol, the strength of which is gradually increased.

The pelagic Tunicata (*Pyrosoma*, *Salpa*, *Doliolum*) are killed and fixed with weak osmic acid, washed in fresh water, and transferred to 35 per cent. and later into 70 per cent. alcohol, or into 5 per cent. formalin.

Simple and compound Ascidians should be narcotized by placing them for some hours in chloralized sea-water containing chloral hydrate 1 in 1,000. They may then be put into strong spirit or 10 per cent. formalin, which should be changed after twenty-four hours, because Ascidians contain much water.*

Mr. A. B. Lee † strongly recommends for Compound Ascidians a process employed by Professor Van Beneden. The colony is placed in clean sea-water for a few hours. When the zooids are expanded, the colony is seized with the fingers and dropped into glacial acetic acid, and left there for from two to six minutes. It is then removed with the fingers, and washed well in 50 per cent. alcohol, and graded into successively stronger alcohols up to 70 per cent. This method avoids the use of steel, and will not injure the fingers if they are washed at once. If used for the species (not many in number) which possess calcareous spicules, other pieces should be preserved without exposing them to the action of an acid.

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* Professor W. A. Herdman states in a letter that he uses 10 per cent. formalin for bulky Tunicata, and 5 per cent. for the more gelatinous forms.

† A. B. Lee, "Microtomist's Vade Mecum," 6th edit., 1905, pp. 12, 461–2.

Plants.

THE directions for collecting and preserving plants are based on those drawn up by Robert Brown; sections have been added on groups requiring special treatment. I am indebted to Messrs. H. and J. Groves for the part dealing with Characeæ, to Mr. Edmund Grove for the special directions on Diatoms, to Mr. and Mrs. Gepp for suggestions for the section on Algæ, and to Miss A. Lorrain Smith for directions for preserving fleshy Agarics.

The present edition is merely a reprint of the third, with a few slight verbal alterations.

A. B. RENDLE.

DEPARTMENT OF BOTANY,
March, 1921.

The collection and preservation of plants is a much simpler process than is generally imagined by those unpractised in it.

The chief circumstances to be attended to are, to preserve specimens in such a manner that the moisture may be quickly absorbed, the colours as much as possible preserved, and such a degree of pressure given to them that they may not curl up in the act of drying.

For this purpose let a quantity of separate sheets of paper be obtained of a folio size.* Common brown paper is upon the whole the best, except for the very delicate kinds, which require paper of a smoother and somewhat more absorbent texture. Blotting-paper, however, especially in warmer climates, would absorb the moisture

* The size of British Museum Herbarium paper is 17½ inches by 11¼. Drying-paper and presses of a corresponding size should be used, and specimens should be disposed so as not to exceed these limits. Applications for a special drying-paper should be made to the Keeper of Botany by travellers in little-known countries.

too rapidly, and by repeated damping and drying would soon be rendered useless. Ordinary newspapers answer the purpose very well.

Two perforated boards or rigid wooden frames (fig. 56), or light presses made of galvanised iron wire, should be provided—one for the top and the other for the bottom of the mass of papers; the perforation or open framework allows access of air to the papers, thus accelerating drying and preventing the plants from becoming mouldy.

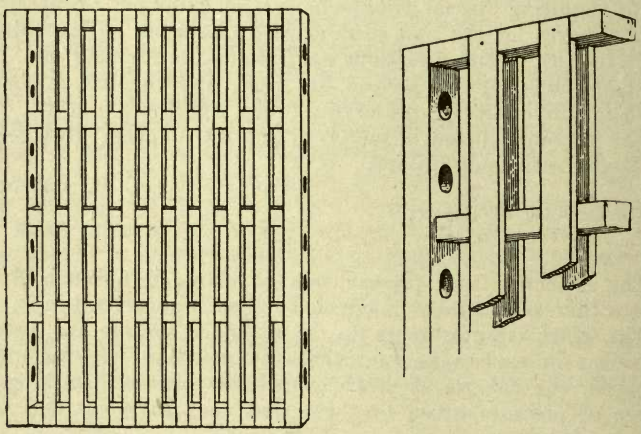


Fig. 56.

For pressure at home, or when stationary for any length of time in a given spot, nothing serves better than a weight of any kind (a folio book, a large stone, etc.) put upon the topmost board; and the great advantage of this is, that the weight follows the shrinking of the plant beneath.

Whilst travelling, three leathern straps with buckles should be procured—two to bind the boards transversely, and one longitudinally. It will be further desirable to have a number of pieces of

pasteboard of the same size as the paper, to separate different portions of the collection, either such as are in different states of dryness, or such as by their hard woody nature might otherwise press upon and injure the more delicate kinds.

Thus provided, gather your specimens,—if the plants be small, root and stem; if large, cut off branches of 1 or 1½ foot long;—selecting always such as are in flower, and others in a more or less advanced state of fruit.

Place them side by side, but never one upon another, on the same sheet, spreading the leaves, etc., so as to allow as little overlapping as possible while still retaining their natural position; and lay upon them one, two, or three sheets, according to the thickness of the plants, or their more or less succulent nature; and so on, layer above layer of paper and specimens, subjecting them then to pressure.

As soon as you find that the paper has absorbed a considerable portion of the moisture (which will be according to the more or less succulent nature of the plants and the heat or dryness of the season or climate), remove the plants into fresh papers, and let the old papers be dried for use again, either in the open air or sun, or in a heated room, or before the fire. In drying papers out-of-doors in countries visited by sudden rains, it is a good plan to insert an eyelet in one corner of each sheet and string the sheets up. This enables them to be gathered in a moment, and prevents their being blown to a distance.

If the specimens cannot be laid down immediately on being gathered, they should be preserved in a tin box, or, failing that, in a rush basket, where they will keep fresh for a day or two, if the atmosphere be not very much heated.

Some very succulent plants, such as Cacti, Sempervivums, Sedums, Orchids which grow on trees, etc., require to have the specimens plunged in boiling water for a few seconds before they are pressed, to destroy life and thus accelerate the process of drying.

Plants with very fine but rigid leaves, such as the Firs and the Heaths, and some with compound winged leaves, may either be treated in the same manner to prevent their leaves falling off or their parts separating, or dried in very hot paper or with a hot iron.

Fleshy stems or leaves may be split lengthwise and the succulent portion scraped out before placing in the press; bulbs, tubers, etc., should be cut in slices.

In many cases, especially in warmer climates, the traveller will find the drying process accelerated by exposing the parcel (hung up and properly secured) to the open air when the weather is favourable, and the circulation of air through it will be promoted if the sheets on which the specimens are laid be placed alternately back and edge. In tropical countries he will find it necessary to shift his specimens at least once a day, and by changing them into hot paper, and crowding such specimens as are dry, he will be enabled to form a considerable collection in small compass and in a very short time. Four or five shiftings will generally be sufficient to complete the process, which is ascertained by the stiffness of the stems and leaves, and by the specimens not shrinking when removed. They should then be placed between dry papers such as ordinary newspaper, and formed into parcels of moderate thickness, and either packed in boxes or well secured as parcels covered with oil-cloth.

Palms, having their fructification and leaves very large, can hardly be subjected to pressure; a few flowers should be pressed, and the whole cluster of flowers and fruit, as well as a leaf, may be simply dried in the air, and afterwards packed in boxes for transportation.

The greater number of cryptogamic plants may be dried in the common way, such mosses as grow in tufts being separated by the hand. But both mosses and lichens, as they can at any future time be expanded by damping, may be dried by the traveller without pressure, and put up, either each species separately or several together, in small canvas or paper bags, carefully marking the place of growth and the date when gathered. (For lichens *see* also p. 170.)

If the fruits of plants are of a small size so as to be capable of being preserved in a herbarium, they should be gathered with the leaves and branches as are the flowers; if of a large size, they should be kept separate.

Dry fruits demand no care, except that those which split into valves should be tied round with a little packthread.

Pulpy fruits are only to be preserved in spirit, or in formalin diluted with from five to ten parts of water. In all cases the separate fruits, whether dry or preserved in a fluid, should have a number attached to them, referring to the flowering specimens of the plant. Seeds, whether for examination or intended to be sown, should be gathered perfectly ripe, put up in brown paper bags, and kept dry in a box.

With the specimens, fruits, and seeds, there should be slips of paper, on which are to be written the uses, native names, and general appearance of the plant, whether herbaceous, a shrub, or tree, and the colour and form of the flowers; its situation, if dry or damp, the nature of the soil, the elevation above sea-level, and the date when gathered.

As soon as a sufficient number of specimens are collected, no time should be lost in transporting them to their place of destination, since, in warm climates especially, they are liable to the attacks of insects. These attacks, which are often completely destructive of the specimens, may in many cases be prevented by pitching the boxes, and by putting in them, or in each parcel, cotton dipped in petroleum, spirits of turpentine, or small pieces of camphor or naphthalene; and the captain of the vessel should be particularly requested to keep them in a dry or airy part of the ship.

Specimens of the woods of from 6 to 8 inches in length, the entire round of the trunk or branch of the smaller, and segments from centre to circumference of the larger kinds, in both cases with the bark, should also be preserved—not only of the more remarkable trees, but also of the woody climbers, which often exhibit peculiarities of structure highly interesting to the botanist. When specimens of woods are preserved, they should be marked with numbers corresponding with the flowering branches of the tree in the collection of specimens; and when flowers cannot be obtained, a small branch with leaves or fruits should always be taken.

Gums, resins, and other remarkable products should also be collected, their uses if known noted, and reference made by numbers to the plants to which they belong.

CHARACEÆ.

The most generally convenient method of collecting Characeæ is by means of a drag and line. The drag consists of a bulb of lead from about ½ to 1 lb. in weight, with three or more hooks of strong galvanised iron wire. The drags with three hooks used by anglers for fishing up lines answer the purpose well. The line should be of stout water-cord about ⅛ inch thick, and twenty yards will generally be found sufficient. Large pieces of water can be much more satisfactorily explored for Characeæ by means of a boat than from the shore, the plants being often confined to a particular part or depth of the lake or pond. In small or shallow pieces of water it is desirable to collect specimens with a walking-stick, or, better still, by hand, as by these means whole plants with the roots can be obtained, while a drag is apt to break up the more brittle species.

Care should be taken in the case of the diœcious species to collect both sexes, and collectors should not content themselves with getting those specimens only which grow at the margin of a pond or other piece of water, these being often small and stunted and sometimes sterile. Most of the Characeæ fruit in the summer, but a few reach maturity in the spring.

It is undesirable to carry the specimens loose in the vasculum. If put as straight as possible when collected, and spread in a thin layer on a double thickness of newspaper, which can then be rolled up, they will carry well, and will, if necessary, keep for days. They must, of course, be kept moderately moist, but should not be allowed to get sodden.

There are few plants of which more beautiful specimens can be made than Characeæ, if carefully treated ; and, on the other hand, there are few which present a more forlorn and draggled appearance when badly dried. The Nitelleæ should be "floated out" in the same way as Algæ ; that is, a sheet of paper should be placed in a vessel of water, and a root or small tuft of the plant (after having been washed) placed on it, and arranged as naturally as possible with the fingers or some sharp instrument. The shallow "baths" used by photographers are excellent for the purpose ; but an oblong white enamelled-iron tray about 2 inches deep is equally serviceable and

more portable. Failing either of these, a large dish or basin may be used. A sheet of perforated zinc laid under the paper will be found of great assistance in removing the specimens from the water. Good firm white printing paper should be used for floating the specimens on. In the case of diœcious species the sexes should not be mixed, but either placed on separate sheets of paper, or perhaps preferably a specimen of each placed side by side on the same sheet.

When the specimen has been removed from the water, it should be drained, and a piece of thin calico or linen (previously washed so as to have no "dressing") should be placed over it, to prevent its adhering to the drying-paper. The calico should be removed when the drying-paper is first changed. With the very gelatinous species waxed paper should be substituted for calico.

Most of the Characeæ can be put into press without "floating out," and for these a doubled sheet of thinner paper is usually sufficient, but the calico should always be used. Characeæ require considerable pressure. A few good fruiting whorls should be kept in a test tube of spirit or other preservative for examination.

Algæ.

Marine Algæ may be gathered by hand, by net, or by dredge.

(1) By hand from uncovered rocks and stones and pools at lowest tide (especially spring tides) and from heaps of *fresh* refuse thrown up by storms. Decaying or bleached specimens should not be collected.

(2) By net from the margin of the incoming tide, especially after a storm. The net should be fitted on a hoop at the end of a rod, the other end of which may be shod with a chisel end for detaching specimens. The net should not exceed six or eight inches in diameter and should be of a fine mesh. It is advisable to wear long waders.

(3) By dredge or grappling hook from the sea bottom even down to depths of 40 or 50 fathoms. For dredging from a rowing-boat Reinke's dredge is very useful (see fig. 57).

Care should be taken to collect where possible the entire plant

with its attachment. Large plants should be kept separate from small ones. The latter may be put straight into a small waterproof bag or pail of sea-water, or, if delicate or particularly choice, into separate wide-mouthed bottles. Glass bottles may, however, cause a nasty injury in case of a fall on slippery rocks. The red Algæ are liable to be spoiled by contact with the coarse brown ones, and should therefore be kept separate.

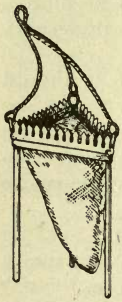


Fig. 57.

If through lack of time or opportunity the specimens cannot be mounted at once for the herbarium, they should be rough-dried as soon as possible by being lightly scattered on paper in a dry, but not sunny, spot or room until they become absolutely dry and shrivelled to the smallest dimensions. They may then be labelled and packed loosely in boxes or tins; and later they can be soaked out and mounted for the herbarium.

If, however, the collector is able and willing to mount the specimens, he should float them out in the manner described above for the delicate Characeæ, making use, however, of sea water and never of fresh water. Where sea water is not easily obtainable, a satisfactory substitute can be prepared by dissolving 3 parts of Tidman's sea salt in 100 parts of water (3 oz. in 5 pints). Great care should be taken to separate and arrange the branches of the smaller and more finely divided specimens with a soft paint-brush in a clear and natural manner, while the mount is being gently drawn out of the water. After the mount has drained for some minutes it should be covered with a piece of well-washed muslin or old cotton material and placed between drying papers under pressure so light as to leave no impress of the muslin or the Alga. In case of very gelatinous Algæ, waxed paper or tracing paper may with advantage be substituted for muslin. The papers and muslin should be changed after five or six hours and again after half a day, when the muslin may be discarded. At least one more change of drying-paper is desirable. The pressure may be somewhat increased as the plants lose their moisture, but should never be heavy.

Notes should be registered on the mounts as to locality, date,

habitat, depth, and if possible as to condition of tide, strength of current or stillness of water, etc. The tendency of collectors is to neglect these data.

Some of the regions from which marine Algæ are most wanted are the Pacific Ocean, China Sea, North Australia, Malay Archipelago, Indian Ocean (including Persian Gulf, Red Sea, and Madagascar), West Africa, and South America.

To obtain the microscopic floating plant-life of the sea and of fresh waters **(Phytoplankton)** a tow-net of the ordinary pattern, made of No. 20 Miller's silk, may be used at any depth from a boat or ship going with little more than steerage way. Surface organisms at sea may be got in excellent condition by pumping with the deck-hose through such a tow-net suspended from a boat-davit, or in less abundance by running the bath-tap through a silk bag for a few hours. To those who employ this method indiarubber hose is to be recommended in preference to canvas or leather hose, on account of impurities discharged from both the latter.

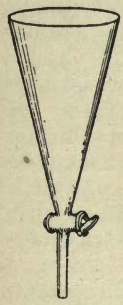


FIG. 58.

In preserving minute Phytoplankton, marine Diatoms, and the like, a fluid preparation is best.* Formalin is the most convenient and portable fluid for general purposes, and should be used in strength of 2 to 4 per cent. solutions. Chromic acid 0·25 per cent. and platinic chloride 0·5 per cent. also give excellent results as fixing and preserving fluids; but where calcareous organisms are involved, alcohol 73 per cent. solution (*i.e.* 40° over proof) is the only permanent preservative. For fresh-water plankton a 2 per cent. solution of potassium acetate containing a trace of copper acetate is strongly recommended. The above solutions should be made up of double strength, and an equal volume of any one of them should be added to the water in which the organisms are living.

Minute fresh-water Algæ and submerged mosses are well preserved in carbolic acid (about 1 per cent.) or in camphor water,

* The contents in the tail of the tow-net should be emptied into a funnel with a stop-cock (*see* fig. 58), and withdrawn below after settling; failing this, by settling and decanting, or by picking up with a dipping-tube.

or weak spirit where these are not to be obtained. Such submerged plants as *Myriophyllum*, *Utricularia*, *Nymphœa*, *Nuphar*, and *Nitella* should be squeezed, and after the water has stood for some time the upper part may be decanted and the sediment preserved. Scrapings from moist and dripping rocks yield good results.

To the special collector of Diatoms some directions may be given in addition to what has been said above.

Diatoms.

The mud of lakes, pools, and backwaters of rivers, and of swampy places on moors, will repay attention. Where it looks yellow, or shows the presence of Diatoms by giving off little bubbles of gas, it should be scraped up by a fine muslin net attached to a wire frame. The contents of the net should be turned out into a pan, stirred well, and the supernatant sediment poured into a wide-mouthed bottle. Repeat this until there is a good quantity in the bottle, then wash the net and pan thoroughly, and try another place.

In alpine and subalpine places the surfaces of boulders in lakes and streams should be scraped in the same way. These are generally much purer gatherings than the muds. Perpendicular rocks by the sides of streams should be scraped, and the rock-faces above the surface of the water should be examined for any little white tufts or patches of Diatoms which have grown there when the waters were higher and have become sun-dried. Wooden cattle- and horse-troughs often yield specimens.

The bottles when taken home should be well shaken, the contents poured into filtering-paper, left to dry, and folded up as they are, labelled with locality, approximate height above sea-level, date, and character of the water, whether fresh, brackish, cold, or thermal.

Water-weeds, Sphagna, etc., growing in lakes and pools, should be gathered, washed, and gently squeezed in water, and the sediment treated like the muds. Floating patches of scum which have risen to the surface, buoyed by bubbles of gas on a warm sunny day, should be secured with the net. These are often rich

in Diatoms. It must be remembered that small quantities are very difficult to manipulate afterwards.

Marine Diatoms from the surface should be collected by tow-net as described on p. 167 under "Phytoplankton."

Ripple-markings on warm, sunny days often exhibit a yellow-brown colour on the sides opposite the sun. This sand should be scraped, and treated in a pan as recommended for the muds. The process should be often repeated, because the proportion of Diatoms to sand-grains is often small. Rock-pools between tide-marks should be examined, and sloping or horizontal rock surfaces scraped. Shells, especially living ones, covered with Zoophytes and small Algæ should be scraped, and the scrapings sent as they are. The contents of the stomachs of Holothurians, Ascidians, and herbivorous Molluscs are often very rich in Diatoms. Dredgings and rubbish from trawling boats are often fruitful in diatomaceous remains which have sunk from the surface.

If the surface of peat deposits shows white patches, a slice should be preserved. Any light-coloured strata of low specific gravity, either under peat or occurring by themselves among other strata, deserve attention.

For Diatoms found on the skin of whales, *see* p. 29.

Fungi.

Hard woody Fungi need no special preparation, beyond keeping them in a dry place. Most of these are found growing on trunks of trees; but when a terrestrial one is met with, it should be dug up with care, since sometimes such forms spring from underground tuberous bodies.

Fleshy Fungi such as the Agarics may be preserved in the following way. Cut away the stalk and place the pileus, gills downward, on a piece of white or coloured blotting-paper and allow the spores to drop. Cover over with a bowl or glass during the process to prevent any disturbance, and leave for some hours. Then gently lift the piece of blotting-paper and float it (spores uppermost) on a mixture of water and gum arabic—the spores will thus be gummed on to the blotting-paper; dry, and cover with tissue paper.

Next cut a thin vertical section through the middle of the stalk and pileus, and dry quickly, under pressure by ironing if need be. This will show form and composition of pileus, gills, and stalk. Then scoop all the soft material out of half of pileus and stem (after having split it exactly through the middle), and dry that in the same way; it will give you the outside of stem and pileus. Add notes as to habitat, consistency, condition (if slimy, etc.), and colour. Indicate colour when possible with water-colour paints. Other fleshy Fungi may be similarly treated. Specimens may also be preserved entire in fairly strong spirit or in formalin diluted with five to ten parts of water. In the case of Phalloideæ, young and mature specimens should be obtained when possible.

Leaf Fungi are best preserved by pressing and drying, and the name of the host-plant should be noted, or if unknown, then a specimen should be taken for identification.

Lichens.

Lichens are very easy to collect and preserve. Crustaceous forms need no special care; portions of wood or rock on which they grow should be detached and the specimens wrapped in soft paper and packed in boxes. Leafy forms should be subjected to slight pressure until dry and then placed between paper in the usual way. Gelatinous forms, being moister, require rather more care in drying and pressing. It is always advisable to secure when possible a portion of the substratum; or failing that, careful notes on the habitat should be made.

Mycetozoa.

Mycetozoa should be dried, and carefully preserved from crushing by fixing them in chip-boxes.

Fossils and Minerals.

Fossils.

Field Observations and Labelling.

1. The scientific value of a fossil depends largely on the accuracy with which the circumstances of its discovery are recorded. Whenever possible, a note should be made, not only of the precise locality, but also of the exact position in the exposed section whence the specimen was obtained.

2. When more than one fossiliferous band is observed in a section, the fossils from each stratum ought to be kept apart, and their exact sequence noted. Measurements of the thickness of the several beds are of great value.

A sketch or diagram of the section should be made, the beds numbered, and a corresponding number (with date) should be added to the label of locality attached to each specimen.

3. Be careful to distinguish between fossils from the regularly bedded stratified rocks of a section, and others which may occur in infilled fissures across those rocks. Instances are known in which the contents of fissures filled in at a comparatively recent geological period are nearly as hard as the surrounding rock. Such filled-up chasms are especially to be looked for in limestones, and can be readily distinguished by the irregular and chaotic arrangement of their fragmental contents.

4. It is desirable to leave the fossil adhering to a fragment of matrix when the rock is sufficiently hard, or at least to preserve the impression left by it on the matrix. In sandstones the counterpart is often quite as valuable as the fossil itself, and shows features not otherwise preserved. When the rock is soft or pulverulent, traces of it retained in the crevices of the fossil are frequently of

value. When the fossil consists of several separate parts (*e.g.* a vertebrate skeleton), a slab showing the parts in natural association is of much greater scientific value than would be the same fragments removed from the matrix. In short, it ought to be possible to verify from the fossil itself the collector's statement as to the deposit in which it was found, and the natural grouping of its several parts.

Photographs or sketches of the fossil *in situ* are most desirable.

In case of the specimen being embedded in a slab of matrix, the position of the slab (whether with its face downwards or upwards) should be indicated.

5. Each specimen (or portion of specimen) ought to be wrapped up separately in paper, protected with cotton-wool or moss, or a small box when necessary, each packed with its own special label, and marked also on the outside. It is advisable to carry a small bottle of red paint (or red sealing-wax dissolved in methylated spirit), and number each specimen or fragment to correspond with a record in a note-book, thus preserving a second memorandum in case the loose label is lost or displaced in unpacking. The red paint is also useful for making streaks and other distinctive marks across the cracks in fissured specimens before they are removed from the rock —a precaution of much service later in finally fixing together the pieces when separated.

6. It is useful to carry several canvas bags slung on a strap, and preserve one for each horizon, while the actual collecting is in progress. The bag can be tied round with string, and labelled outside.

Hints on Collecting from Certain Formations.

1. It must be remembered that in certain slaty rocks the planes of fracture are not the original bedding-planes, but surfaces induced by cleavage. The original bedding can frequently be detected by colour-streaks, and fossils must be looked for on planes parallel with the latter.

Such slaty rocks, though apparently barren, may prove (like the Welsh Cambrian rocks) to be very fossiliferous, if the organic remains

are sought for on the *edges* of slabs, sometimes at right angles to the cleavage planes.

2. In compact limestones fossils are often difficult to discover, except on weathered surfaces. The old faces of quarries, exposed natural sections, and stone walls should therefore be examined with care.

Even when limestones appear to be unfossiliferous, it is well to examine them—and especially the cherty bands and nodules so frequent in them—with a good hand-lens to detect microscopic organisms. Shells of Foraminifera and Radiolaria, spicules of Sponges, etc., may frequently be detected by a lens on smooth, wetted surfaces.

3. Similarly, apparently unfossiliferous clays are not to be neglected. Samples may be taken and "washed" at home, the result being frequently abundant remains of Foraminifera and Ostracoda, etc., from marine deposits, and seeds of plants from comparatively modern fresh-water deposits.

4. When a formation contains nodules or concretions, special attention ought to be paid to these. They have usually been formed round decaying organic matter, and a large proportion of the best-preserved fossils occur in them.

The clay-ironstone nodules found in the beds associated with seams of coal usually contain remains of coal plants, insects, and Crustacea enclosed within them, often of great beauty.

Many concretions enclose fossil fishes. The late Mr. Charles Moore found, after long experience, that the nodules of White Lias, containing fishes, were most successfully opened by first breaking them in two near the centre, and then splitting open each half at the inner transverse fracture. The two halves of the split surfaces were afterwards glued together.

The interior of chalk flints and nodules of chert from the Greensand frequently have hollows containing loose whitish or greenish powder. This should be collected, for it usually has small organisms such as Foraminifera or Sponge-spicules scattered through it; and they may be obtained by levigating the loose powder, or, where the material is silicified, by treating it with dilute acid.

5. Ploughed fields or fields in the autumn when the crops have

been gathered, frequently yield fossils in those instances in which limestone or other rocks are near the surface. Molluscan and other shells and many other calcareous fossils often become silicified, and are thus rendered more durable than the limestone matrix; and they remain when the rest of the rock has been dissolved. Thus it happens that nodules and stones picked from the surface of fields for the repair of roads, etc., often contain good fossils; and heaps of such materials by the roadside will repay careful scrutiny.

Treatment of Fossils in the Field.

1. As a general rule, it is best to do the least possible trimming and cleaning of a fossil in the field. Final preparation for the cabinet can be far better done at leisure afterwards.

2. Large friable specimens, such as vertebrate skeletons, large Ammonites, or groups of shells, in a matrix which is only moderately hard or liable to fall to pieces on drying, need special treatment. The fossil ought to be first carefully uncovered as it lies in the rock. Then thin paper may be gently pressed over, covering the whole, and as far as possible filling every crevice. Next, plaster of Paris must be poured over this prepared face, and allowed to harden in a moderately thick layer. Finally, the specimen may be excavated and transported as a slab, the plaster covering serving as an adequate support. N.B.—If paper be not used, the plaster cannot be readily removed from the fossil, and may completely damage it.

Strips of wood, or thin iron rods, fixed down to the specimen by plaster of Paris and string, may be used, to give rigidity to friable or heavy specimens in lifting them from the quarry to a waggon for transport.

3. Some large specimens—*e.g.* bones in Pleistocene deposits—need to be hardened before removal from the matrix. This can be done by uncovering the upper face of the fossil, and pouring slowly upon it a warm, weak solution of gelatine or glue, or the preparation known in commerce as "soluble glass." Then, after adequate time for drying, proceed as above (No. 2).

4. Bones which are only moderately delicate can be transported best swathed in long strips of linen or calico (like the Egyptian

mummies), and, after wrapping, this may be hardened by the copious application of ordinary flour paste; or the strips may be dipped in flour paste before winding them round the bones. Melted paraffin wax is sometimes found useful to hold together fragile specimens.

5. In cases where the specimen, from either its size or condition, must be got out in pieces, or in the case of a skeleton in separate bones, *each part* of such bone, or of such more or less entire skeleton, should be carefully marked with a number corresponding to one on the adjoining part, and also with that on a rough sketch in the traveller's note-book. Red or white paint (carried in a tube) can also be used to mark the connecting-points in a skeleton or in the parts of a single bone.

Preparation of Fossils.

1. All friable fossils, such as shells in Tertiary or recent clays, need immediate attention. They may be slowly dried in the sun or in an oven, and hardened by treatment while still warm with a weak solution of gum-tragacanth. This is better than gum-arabic, because it does not leave a glossy surface.

2. Fossil leaves in clay curl up on drying, and are frequently destroyed. These may also be preserved by the application of gum-tragacanth or a thin solution of gelatine.

3. Friable bones are best hardened by first warming, and then dipping for a few moments in a warm, weak solution of gelatine.

4. Pyritized fossils cannot always be preserved. When decaying, soak for twenty-four hours, or boil if possible, in a strong solution of washing soda to dissolve the sulphate of iron and free acid; wash out thoroughly in changes of distilled water; pass through petrol or benzol, into melted paraffin wax.

5. Ordinary gum with a little glycerine, or glue, may be used for mending small specimens. Shellac is too brittle for most purposes. The best cement for large specimens is liquid glue, with a small admixture of plaster of Paris. Dental cement is very useful, especially when it is desired to fix a fragment so that it can be separated again.

Packing Fossils.

1. In packing fossils always use resilient material, such as crumpled paper, shavings, straw, moss, grass, or cotton-wool—never sawdust, sand, or grain (chaff). Boxes should be tightly packed, leaving no room for the shifting of the contents.

2. Boxes are better small and numerous than large and few. Heavy cases suffer more from concussion in transport than small boxes.

Small boxes, carefully packed and placed in a larger case, will travel well.

The opening of cases by Customs officers in docks and on the frontier of foreign States is often more fatal than a very long journey to the contents of boxes. Every effort should be made to ensure lenient treatment of collections.

Minerals.

From the collector's point of view, Minerals differ in many respects from both Animals and Plants: the individuality being little pronounced, a specimen may be broken in two, and yet often be as satisfactory as before in its illustration of the characters of the material; the characters themselves are independent both of climate and seasons and of mere longitude and latitude; the material, after collection, is comparatively permanent and, in most cases, free from that liability to decay which is a special feature of organic matter.

Meteorites.—Of the mineral products of Nature some are interesting as having fallen from the sky (meteorites): most of these (meteoric stones) are of grey stony matter, which is completely covered with a thin black crust, and contains metallic particles (meteoric iron) dispersed through it; the others consist of metal (meteoric iron), which, though containing on the average about 10 per cent. of alloyed nickel, has an aspect like that of the iron of commerce. As native iron is extremely rare, any natural material

consisting either wholly or partially of metallic iron is of special interest and worthy of collection.

Minerals.—The specimens which show the characters pertaining to mineral species and varieties in the most perfect way are found, not at the earth's surface, but in the course of the working of mines and quarries. Where, however, rocks are well exposed, as in natural cliffs or in road and railway cuttings, especially those which have been recently excavated, good mineral specimens may be found in fissures and cavities. In the beds of streams also and at the bottom of valleys the traveller in little-known regions may find specimens of gold, precious stones, metallic ores, etc., indicating the probable presence of the same minerals in the neighbouring rocks.

Rocks.—Rock-specimens are of most value when collected, in connection with a complete survey and description of the region, by one who has given special attention to the study of mineralogy and geology. A traveller, however, in a region which is comparatively unknown, or which contains neither mines nor quarries, may do good service by collecting material representative of the rocks met with during his journey. Such material should be taken, not from the margin of the rock which has been long exposed to the action of the weather and is more or less altered, but from the inner part showing uniformity of character. To break off such specimens, the traveller should provide himself with a hammer of which head and shaft are reasonably proof against fracture. "Mineralogical hammers" are articles of commerce, and are of various weights and sizes; the head is of well-tempered steel, one end of it being flat and square with an edge about 1 inch long, the other end having the shape of a chisel, the chisel-edge, also about 1 inch in length, being at right angles to the shaft: for most purposes a hammer of 2 pounds weight is sufficient. Strong chisels, 4 or 5 inches long, are also occasionally useful. A small trimming-hammer, from $\frac{1}{2}$ to $\frac{1}{4}$ pound in weight, is convenient for use in the reduction of specimens to a proper size and shape. The size adopted for the specimen must depend largely on the sizes of the individual mineral constituents of the rock, since the specimen is to illustrate the average characters of the mass, and also on the conveniences for transport;

a good average size, if the specimens are intended for exhibition, is: length 4 inches, breadth 3 inches, thickness from ½ to 1 inch. As rock-material is very heavy, the reduction in size should be made at the place itself; another piece of the rock can then be immediately got, if by any mischance the specimen be spoiled in the course of the trimming. When a rock shows variations of character, specimens should be selected in illustration thereof.

The interest of a rock-specimen lies very largely in the relations of the mass of which it is a part to the other rock-masses in the district; unless information as to the locality of the mass to which the specimen belonged is preserved, the specimen itself generally becomes valueless; for this and other reasons water-worn pebbles are not worthy of transport. Hence it is important to specify as precisely as possible the place from which each specimen has been broken, and also to take precautions against the possibility of a subsequent confusion of the specimens. For this purpose a gummed label should be fastened on each specimen immediately after it has been trimmed, and a number should be written thereon referring to a corresponding entry in a note-book in which all the memoranda relative to the locality and the specimen are recorded: among these may be included the hour and the date when the specimen was got, as giving a rough indication of the relative positions of the different masses on the line of route. The specimen should then be wrapped in newspaper to prevent friction with others; and as a measure of precaution against the loss of the note-book and also as a convenience, the locality should be specified on the inside of the wrapper. It is also convenient if the wrappers of specimens from each particular district are distinguished by some external mark.

The specimens may be stowed in manilla bags, which are then sewn sufficiently tight to prevent the shaking about of the contents. Wooden boxes should be small and strong, for large boxes containing rock-specimens are almost unmanageable during transport. Paper or straw makes good packing-material; but sawdust is useless, as the specimens accumulate at the bottom of the box with the sawdust above them.

A mineral specimen comprising delicate crystals should be

wrapped first of all in soft tissue-paper, next in cotton-wool, and lastly in newspaper; it may then be enclosed separately in a small box, which may be put with others in a larger one.

Before collecting specimens which offer difficulties as regards transport, the traveller will do well to spend some time in the Mineral Gallery, and to see for himself the kind of material which is found useful for exhibition and study.

Worms.

I.—Introductory Remarks.

A.—On Collecting.

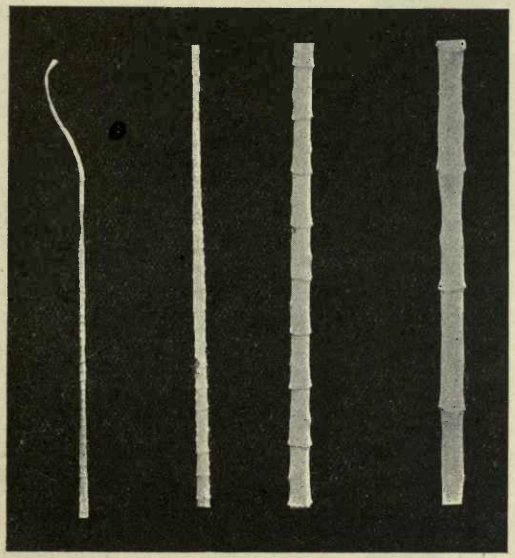
The term "Worms," as here used, embraces a great many animals which bear very little resemblance to the popular conception of a worm. Some little idea of their variety and of the situations in which they are most likely to be found may be gathered from the lists given below.

It will be seen that the parasitic groups are A 2 and 3, C, D, E, on pp. 183–4, and those mentioned on pp. 191–2, but other groups may also include parasitic members.

The majority of these are internal parasites of vertebrate animals; but their position in their hosts varies very greatly. Many live in the alimentary canal, but many occur in other cavities and organs of the body, *e.g.* the heart, liver, lungs, kidneys, bladder, body-cavity, nasal cavities, or even in the blood-vessels, bronchial tubes, and among the muscles and connective tissue. Some of the Trematodes and Leeches are external parasites of fishes and other aquatic or amphibious animals, and may be found attached to their skin, especially on the fins, or on the gills and in the cavity of the mouth. Hence one must not be content merely to open the intestines of an animal and make a hasty examination there, but all parts of the animal ought to be inspected. Even the connective tissue between the skin and flesh often contains parasites. Filariæ (Nematodes), for instance, often choose this situation, and the larval forms of various other parasites may be discovered in similar positions, where they lie enclosed in capsules or "cysts." When found in the connective tissue or in the peritoneum covering the internal organs and body-cavity, or in the walls of the stomach,

etc., it is sometimes advisable to cut out and preserve the cyst with a small portion of the surrounding tissue.

It is worth while to collect all parasites seen, since it is often



a *b* *c* *d*

FIGURE 59.
Portions of an adult Tapeworm, *Taenia serrata*, natural size. *a*, the head (scolex) and some of the young segments; *d*, the most fully developed (gravid) segments, near the hinder end of the worm; *b*, *c*, portions from intermediate regions. [CESTODA.]

only by the most careful microscopic investigation that one species can be distinguished from another.

Some small Nematodes parasitic in the intestines, more especially of birds, are so fine that they are difficult to see unless some of the contents of the intestine or cæca are shaken up in salt solution

or water, when the little hair-like creatures can be picked up with a needle, to which they adhere readily. For many Nematodes it is a good plan to shake or stir up the intestinal matter in a vessel of weak salt solution, and allow it to stand, when the worms will sink to the bottom, and the dirty fluid can be poured off. Clean fluid may then be added, and the process repeated until the worms are clean and free from *débris*.

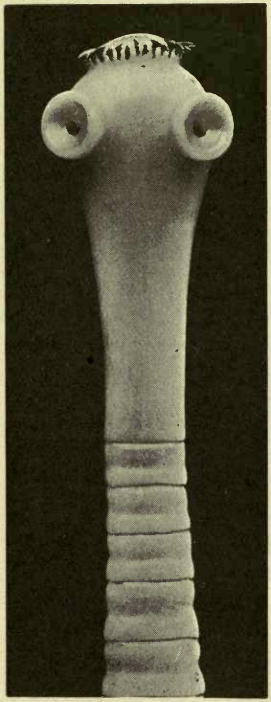


FIGURE 60.
The head (scolex) of a Tape-worm, greatly enlarged, showing the hooks and two of the suckers. From a wax model of *Taenia solium*. [CESTODA.]

In collecting Tape-worms the intestine of the host should be slit up with a pair of scissors (preferably blunt-ended) and the contents scraped out gently with the back of a knife or scalpel. The scraping ought to be so managed as to secure the heads of the worms, which may be attached more or less firmly to the lining of the intestine. If any are very firmly attached a small portion of the intestine may be cut out round them, and placed with the worms in a dish of weak salt solution, when by gentle persuasion, by means of scalpel or needles, the worms may be made to loosen their hold. In general it is best to place the mass of worms and ingested matter in a tall vessel of salt solution, any floating lumps being broken up, and the worms then washed by gentle shaking, as directed on pp. 204, 206.

B.—On Labelling.

It is extremely important to label all specimens fully.

The label bearing data as to the host in which a parasite occurred, its position in the host, the locality, date, and any other observations

made at the time of collecting, is almost as valuable as the specimen itself; a specimen without its label is practically useless. These remarks, of course, apply to free-living forms as well as to parasites—notes as to the position in which they were found should always be given. The method of preservation used should also be stated. In addition to the labels giving such information, it is well to number the specimens, and to keep a note-book with full notes of each specimen or set of specimens opposite its number.

In the case of parasites, the species of the host (if known) should always be given. If unknown, an accurate description of it, and if possible a drawing, will help greatly in the labour of determination. In some cases (*e.g.* small Fishes, Reptiles, Mammals, etc.) it would be well to preserve the host as well as the parasite, giving it a corresponding label and number.*

Labels should be written clearly with a soft lead pencil on unsized paper, and placed in the preserving fluid with the specimens. Ordinary *ink* will not do for this purpose, as it will wash out. Certain kinds of waterproof Indian ink, however, are good, if allowed to dry thoroughly before being placed in the liquid. In some cases an additional label in ink may be placed outside the bottle.

II.—Scientific and Popular Names of the chief Groups of "Worms."

A. PLATYHELMINTHES (Flat-worms). Including:—

1. TURBELLARIA (Planarians).
2. TREMATODA (Flukes).
3. CESTODA (Tape-worms).

B. NEMERTINEA (Long unsegmented worms, mostly marine).

C. NEMATODA (Thread-worms or Round-worms).

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* Fishes, Amphibians, Reptiles, &c., are best preserved in spirit; in the case of Birds and Mammals the skins must be preserved, and the skulls of Mammals should be dried and labelled to correspond with the skins. (*See* "Instructions for Collectors," Nos. 3, 2, 1, pp. 46, 30, 9.)

D. NEMATOMORPHA or GORDIACEA (Hair-worms).

E. ACANTHOCEPHALA (Including *Echinorhynchus*).

F. CHÆTOPODA (Bristle-worms).

Including :—

1. OLIGOCHÆTA (Earthworms and their allies).
2. POLYCHÆTA (Marine bristle-worms).

G. GEPHYREA.

H. HIRUDINEA (Leeches).

I. PHORONIDEA (*Phoronis*).

J. ENTEROPNEUSTA (*Balanoglossus*, etc.).

Some of the distinguishing features of the groups mentioned above are outlined in the following

BRIEF SYNOPSIS OF THE CHIEF GROUPS OF WORMS.

A. PLATYHELMINTHES. Animals of flattened shape, their viscera not contained in a "body-cavity." The alimentary canal, which is either simple or branched (if present), has no anus or vent. Mostly aquatic or parasitic; exceptionally living on land in moist situations. These include :—

1. TURBELLARIA (*see* Fig. 72). Usually with soft, oval or elongate, unsegmented body, covered with minute cilia, or vibratile "hairs." Mouth often in centre of ventral surface, or even further back, with protrusible tubular pharynx. Alimentary canal simple or much branched. Chiefly aquatic (marine and fresh-water); some terrestrial, living in damp places, generally under logs or stones.

2. TREMATODA (*e.g. Fasciola hepatica*, the well-known Liver-fluke of the Sheep.—*See* Fig. 61). Internal or external parasites; usually of oval shape. Unsegmented. With suckers and sometimes horny hooks for attachment to host. Alimentary canal bifurcate, sometimes branched.

3. CESTODA (*e.g. Tænia* of various species, parasitic in man, dog, etc.—*See* Figs. 59 and 60).

Elongate parasitic creatures, of ribbon-like form, with a rounded

" head " bearing suckers, or hooks and suckers, followed by a series of segments increasing in size posteriorly. The hinder segments are generally full of eggs. The larval or young forms (*see* Fig. 62)

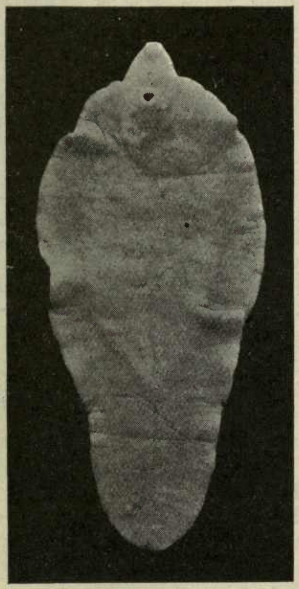


FIGURE 61.
Fasciola hepatica, the Liver-fluke of the Sheep and Ox, seen from below and enlarged about 2 diameters. The ventral sucker is visible at a short distance behind the terminal mouth. In some related species it is situated further back. [TREMATODA.]

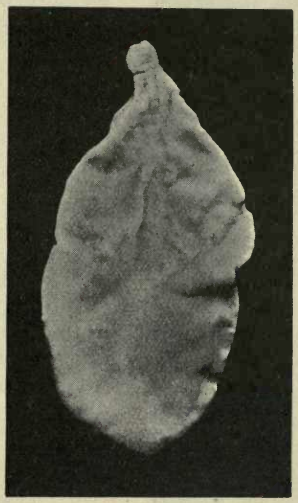
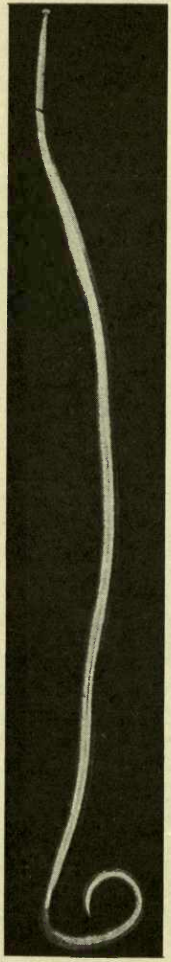


FIGURE 62.
A "Bladder-worm," *Cysticercus tenuicollis*, enlarged about 1½ diameter. This is the larval stage of one of the common Tapeworms of the Dog, and is found in the lining of the body-cavities of Sheep, Cattle, etc. [CESTODA.]

of these worms are found as bladder-like " cysts " of various sizes embedded in the organs (*e.g.* the liver) of some vertebrate or invertebrate animal which is liable to be eaten by their final host. Alimentary canal absent in all stages.



[*Note.*—In collecting Tapeworms great care must be taken to find the head (Figs. 59 and 60), which is very minute and easily broken off, as it may be attached firmly to the host's tissues. (*See* p. 182.)]

B. NEMERTINEA (*see* Fig. 73). (Such as *Lineus* of the seashore.) Unsegmented, cylindrical or somewhat flattened worms, capable of great extension and contraction. Sometimes several yards in length when extended. Possessing a remarkable protrusible proboscis, in a sheath lying above the alimentary canal. Mostly marine, rarely on land or in fresh water, living under stones, etc.

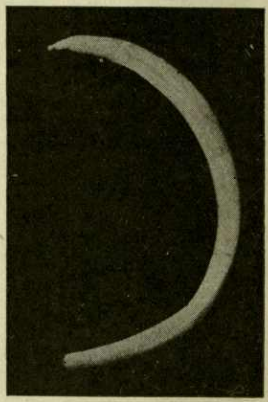


FIGURE 64.
Echinorhynchus gigas, natural size, of the Pig. This is a male specimen, the female being considerably larger. [ACANTHOCEPHALA.]

C. NEMATODA (*see* Fig. 63). (Such as *Ascaris lumbricoides*, the largest round-worm found in man.)

Mostly parasitic worms of elongated form, with flexible but not extensible, cylindrical, unsegmented body. (There are many free-living Nematodes, but these are mostly very

FIGURE 63.—The large Nematode, *Ascaris megalocephala*, natural size, of the intestines of the Horse. This specimen shows the curvature of the tail, characteristic of the male sex of many Nematodes. [NEMATODA.]

minute, living in water or in the soil; some are also parasites of plants.) Tail of *male* nearly always curved downwards, and provided either with a membranous expansion, or with curved horny spicules, or both.

D. NEMATOMORPHA (Gordiacea) (*see* Fig. 71). Extremely long, thin, wiry-looking worms, traditionally compared to "animated horse-hairs." Parasitic at first in the body-cavity of insects; afterwards emerging from them to lead a free life, usually in fresh water.

E. ACANTHOCEPHALA (*Echinorhynchus*, etc.—*See* Fig. 64). Unsegmented, cylindrical worms, more or less resembling Nematodes, but having a proboscis armed with many hooks (*see* Fig. 65), with which they attach themselves to the tissues of the host—usually to the lining of the stomach or intestines. Larvæ in cysts, usually in insects or crustacea, sometimes in fishes, preyed upon by the final host. Alimentary canal absent.

FIGURE 65.

The "head" end of a typical *Echinorhynchus*, greatly magnified, showing the cylindrical proboscis covered with hooks. [ACANTHOCEPHALA.]

F. CHÆTOPODA. Body divided into a number of "rings" or segments, each of which is provided with certain groups or rows of bristles.

1. OLIGOCHÆTA (Earthworms, etc.). Chiefly living below the surface of the soil (often crawling on the surface after rain, etc.), or among rotting timber or other vegetation. Others, of small size, in fresh water, or in mud at the bottom of ponds and streams.

2. POLYCHÆTA (*see* Figs. 66, 67 and 74). Each segment may bear a fin-like expansion on each side, from which bristles project fanwise. These expansions may be wanting, or confined to the front end of the body, in forms which inhabit tubes.

Marine. Some live under stones, or buried in sand at low-water mark; many in tubes of their own construction, attached to solid objects under water. The tubes are of very various appearance, some being hard and chalky, others covered with sand-grains, bits of shells, seaweed, etc., others quite transparent.

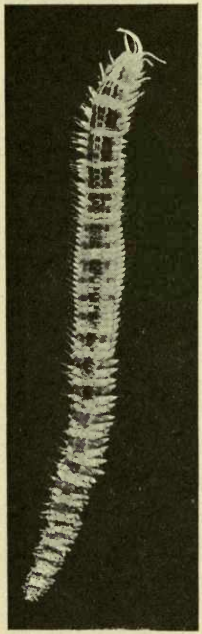


FIGURE 66.
An example of a free-living Polychæte worm, *Lepidasthenia elegans*, slightly enlarged, showing the characteristic paired appendages. [CHÆTOPODA.]

Many of the tube-living worms (*see* Fig. 67) have a flower-like crown of feathery "gills" on the head, which can be protruded from the opening of the tube.

A few Polychætes lead an entirely free-swimming life at the surface.

Certain forms, rather unlike the ordinary conception of a "worm," are included in this group (Polychæta)—such as the Polynoids, some of which are of wood-louse-like shape and appearance; and *Aphrodite* ("Sea-mouse") and its relatives, which are thick-set animals covered with strong bristles and beautifully iridescent hairs (*see* Fig. 74).

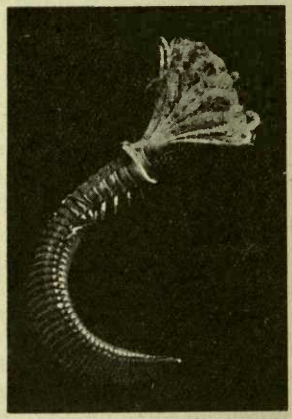


FIGURE 67.
One of the tube-forming Polychætes, *Sabella bombyx*, slightly enlarged. The specimen has been removed from its tube, and shows the crown of tentacles. [CHÆTOPODA.]

G. GEPHYREA (*see* Fig. 68). Marine forms, usually with a simple distended sac-like body, which shows no external traces of segmentation. Sometimes a crown of short tentacles may be seen

expanded at one end. The viscera are enclosed in a spacious body-cavity.

H. HIRUDINEA (Leeches). Worm-like segmented animals, narrower at the head end than at the tail, and having a rounded sucker at each end. External, temporary parasites mostly found on vertebrates, sometimes entering the mouth or nose; living in water (either fresh or salt) or on land in moist places, sometimes climbing on to low bushes, etc.

I. PHORONIDEA (*see* Fig. 69). Unsegmented worms living in tubes, commonly found associated in large numbers. Tube membranous, sometimes covered with mud and other foreign substances. The mouth is in the middle of a terminal crown of tentacles, arranged on a more or less obviously horseshoe-like plan. Alimentary canal U-shaped, the intestine running up by the side of the œsophagus and opening near the mouth. The blood is red, with conspicuous red corpuscles.

Marine. May be found attached to solid objects in shallow water, or inhabiting tunnels bored in calcareous rocks, shells, etc.

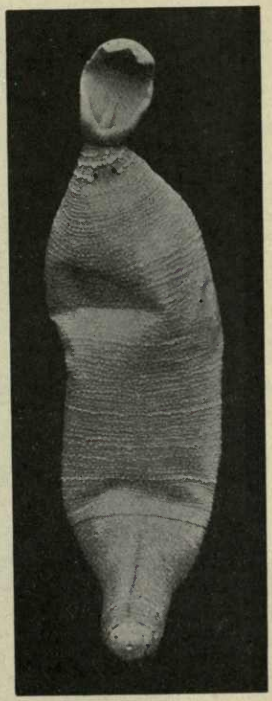


FIGURE 68.
Echiurus vulgaris, the "Spoon-worm," slightly enlarged. [GEPHYREA.]

J. ENTEROPNEUSTA (*see* Fig. 75). Soft-bodied worms which may have a strong odour of iodoform. The front end has the form of a conical or cylindrical "proboscis," which is followed by a short region termed the "collar," encircling the mouth. The rest of the animal, unsegmented and often of considerable length, is composed of several distinct regions, the first of which is often produced into

large lateral flaps. A double series of pores occurs on the back or at the sides of this " branchial " region.

Marine; to be looked for on sandy shores at extreme low tide-mark.

FIGURE 69.
A portion of a crowded colony of *Phoronis*, seen from above and slightly enlarged. The tentacles of the individual worms are not fully expanded. [PHORONIDEA.]

[*Note.*—The body of Enteropneusta is so easily injured that great care is required to obtain complete specimens ; but they are worth preserving if the front half can be obtained in good condition.]

III.—Other Parasites which are liable to be confused with Worms.

When searching, by dissection or otherwise, for parasitic worms, it is not improbable that various other parasites of more or less worm-like appearance will be found.

The importance of collecting *everything* of this kind, especially if there is any question as to its identity, cannot be too strongly emphasised. Hence a brief reference is made here to some of the parasitic creatures which bear some resemblance to worms.

Certain parasitic Arthropods, in which the limbs are degraded or entirely lost, resemble worms in general appearance and are commonly confused with them. Among these may be mentioned the insect larvæ or MAGGOTS, which make their way into the mouth, nostrils or stomach, or under the skin of Mammals, including Man. These are the larval stages of certain Flies, and most of them attack Ungulates—(Horses, Cattle, etc.). Some, like the " Warble " flies, raise tumours of considerable size under the skin, in which the older larvæ live, and from which they eventually emerge to pupate. The so-called " Screw-worm " similarly attacks Man. In other cases, like the *Gastrophilus* of the Horse, the eggs swallowed by the animal hatch in its stomach, and the larvæ thereupon attach themselves as internal parasites to the stomach-wall. They are true maggots and have the usual shape of such creatures, tapering in front and broadened behind, and armed with various rings of spines encircling the body.

The PENTASTOMIDA (*Porocephalus*, *Linguatula*, etc.) are curious worm-like creatures (*see* Fig. 70), of doubtful affinities, usually considered to belong to the Arachnid group, *i.e.* to be allied to Spiders and Mites. But in general appearance they resemble worms, having a comparatively soft elongated body, without limbs,

and the head being armed with two pairs of sharp, horny hooks. In their immature stages they may occur enclosed in cysts among the tissues of almost any part of the body, and in almost any Mammal or Bird, or living free in its various cavities, more especially the general body-cavity. The adults usually occur in Snakes or other carnivorous Reptiles, mostly in the lungs of their host. A few inhabit the nasal cavities of mammals, especially of Carnivora.

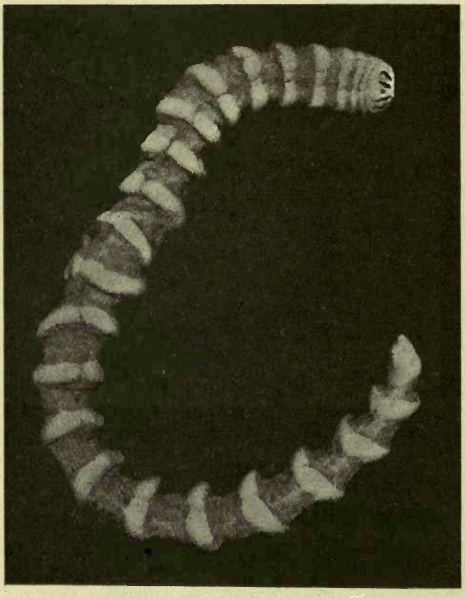


FIGURE 70.
A large Pentastomid, *Porocephalus*, found in the Puff-adder; natural size. [PENTASTOMIDA.]

Parasitic CRUSTACEA may be mistaken for worms. They are found mostly on Fishes and Whales, or on other Crustacea, Mollusca and other aquatic invertebrates; and they may assume a very different appearance from a typical Crustacean. The body may be reduced to a mere soft sac, without appendages, or with only vestiges of them. Sometimes there is a pair of elongated bags of eggs attached to the body, and looking almost like a pair of legs, or like a pair of long strings. These parasites are very commonly found, for example, clinging to the gills of Fishes.

Any of the above-mentioned creatures may be safely treated by ordinary methods of killing, such as alcohol or corrosive sublimate, and preserved in alcohol.

Insect-larvæ may be killed by immersion for a *few seconds* only in boiling water, and then placed in weak spirit, in which they are to remain till hardened (two or three weeks). They can finally be transferred to stronger spirit.

IV.—Habitat of Worms.

The following is intended as a rough indication of what may be looked for in a particular kind of locality :—

(i) *Inland localities.*

(*a*) Parasitic worms.—Any kind of mammal, bird, reptile, amphibian, or fresh-water fish may be found to harbour parasites of many kinds. NEMATODES, TREMATODES, CESTODES, and ACANTHOCEPHALA occur in all these groups of animals, either in their larval or adult stages. As a rule, dissection is the only method of obtaining them, a special search being made in the alimentary canal. But some of the TREMATODES attach themselves to the skin of fishes, amphibians and reptiles. LEECHES are sometimes found adhering to animals (*e.g.* Frogs) which have recently been in or near water. Reptiles, especially Snakes, are sometimes found to harbour *Porocephalus* (*see* Fig. 70), a wormlike creature, which usually occurs in the lungs of its host. Other parasites of this group are found in mammals and birds (*see* p. 192).

Molluscs frequently contain the immature stages of TREMATODES and, less often, of CESTODES.

Insects, such as beetles, grasshoppers and flies, often harbour the immature stages of "HAIR-WORMS" (Gordiacea, Fig. 71, and *Mermis* and its allies, Nematode worms of somewhat similar appearance). These live coiled up in the body-cavity of the host. The adult stages of these worms should be obtained, and if possible some knowledge acquired as to their eggs and larvæ, and the mode of infection of new hosts by the larvæ. It is recommended, therefore, that when these worms are

seen emerging from insects, or found crawling about, an attempt should be made to keep them alive for a time in damp earth, water, etc., in the hope of learning more of their life-history, as the mature stage is usually only reached after leaving the insect host. Small NEMATODES are also parasitic in insects, but usually require the microscope for their detection. Insects and Crustacea also harbour larval CESTODES, TREMATODES and ACANTHOCEPHALA.

(*b*) Fresh-water worms.

TURBELLARIA are commonly found in any standing water, crawling on water-weeds or on the bottom, or even upside down on the surface-film. Since many of them are carnivorous, and like decaying matter, they may sometimes be caught by sinking a pot of dead earthworms in a pond, drawing it up after a day or two and collecting the Planarians that have been attracted by it.

Fresh-water fishes,* amphibians, etc., as mentioned above, should be examined for parasites. Some of the Insects and Crustacea also harbour NEMATODES, NEMATOMORPHA and larval stages of other parasites.

NEMERTINEA are rare in fresh water, but may be found occasionally.

Many NEMATODA occur in fresh water, in the mud at the bottom, or among plants, but these are chiefly of microscopic size.

NEMATOMORPHA habitually pass their adult stage of existence in fresh water, sometimes in standing water, sometimes in quite rapid streams. They may often be found tangled together (*see* Fig. 71) in great numbers, and twisted round weeds, etc., on which their eggs are laid.

The fresh-water CHÆTOPODS are practically all OLIGOCHÆTA, chiefly small forms, living in the mud round

* Fishes frequently harbour parasitic Crustacea, especially on their gills. These parasites should, if possible, be preserved, with a note of the position in which they were found, and information about the "host."

the roots of plants growing in or near the water. Samples of mud from the bottom of any pond, ditch or stream may contain many of these worms. Some even occur as "parasites" in the gill-chambers of crabs and crayfishes. POLYCHÆTA are exceptionally found in fresh water, and are most likely to be obtained by dredging in large lakes In brackish water POLYCHÆTES are numerous, living in the mud, under stones, etc., as do those of the sea-shore.

LEECHES are often abundant in ponds, ditches and streams, where they swim with an undulating movement, or attach themselves to solid objects, and walk like "looper" cater-pillars.

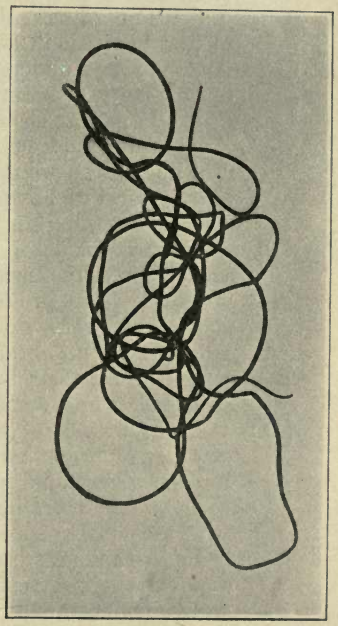


FIGURE 71.
A tangled mass of *Gordius*, natural size. [NEMATOMORPHA.]

(*c*) Land forms.

A number of PLANARIANS (*see* Fig. 72) crawl about in moist places, or may be found among wet vegetation, such as mosses, or under stones and decaying logs. Some of them suggest slugs, others are more elongated, but they are to be recognised by their extremely soft and slimy bodies, having no tough skin like molluscs or other worms. Land Planarians are chiefly, but not exclusively, tropical.

NEMERTINES are rare on land, but one or two have

been recorded. They are likely to be found in wet places under stones, etc.

NEMATODES of minute size are abundant in soil and among roots of grasses and other plants. Some are parasitic on plants, and form galls and other diseased growths on grasses, etc. *Mermis*, as already mentioned, is at first parasitic in Insects, but after emergence from them is to be found underground or crawling about on the soil or on plants, sometimes in large numbers, especially after rain. It resembles *Gordius* in its very wiry appearance.

GORDIUS and its relatives are also sometimes found crawling on the ground, among dead leaves, etc., especially in wet forest districts.

OLIGOCHÆTA (Earthworms and their allies) are abundant everywhere in damp soil, under stones, or among rotting vegetation, sometimes even in the accumulated water and vegetable *débris* in hollows in the branches of trees. Many species are very small and inconspicuous. The earthworms may be obtained by digging, but many of them emerge from their burrows after rain, and may then be collected, while some species habitually lie with part of their bodies out of their holes at night, except in frosty weather or bright moonlight. They may be caught with forceps when found in this position, but are very sensitive to light and vibration, and dart back into their burrows with astonishing speed if disturbed.

LAND-LEECHES occur chiefly in the tropics, lying in wait for their vertebrate prey, either on the ground or on forest undergrowth, always provided that the situation is moist. They often attack man and domestic animals passing through such places.

(ii) *Marine localities.**

(*a*) Parasites. As on land and in fresh water, all kinds of

* Much valuable information about the collection and preservation of marine organisms will be found in a most useful book, "Science of the Sea," issued by the Challenger Society. London: John Murray, 1912. 6*s*.

FIGURE 72.
A land Planarian, *Geoplana fryi*, natural size. [TURBELLARIA.]

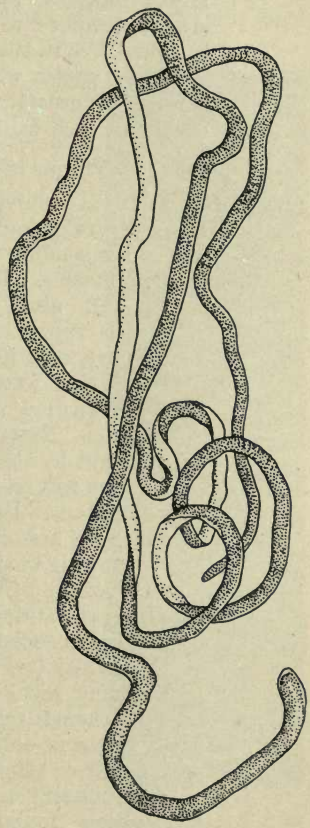


FIGURE 73.
A Nemertine, *Eunemertes gracilis*, enlarged, in a characteristically twisted position. NEMERTINEA.]

mammals, birds, reptiles, and fishes may be examined for PLATYHELMINTHES, NEMATODA, ACANTHOCEPHALA, and HIRUDINEA (*see* pp. 184–189). The last-named are not always attached to their hosts (usually fishes), but may be found free in the water, or on stones and weeds.

It is worth while to examine the gills and body-cavities of crustacea (crabs, etc.) and the cavities and organs of shell-fish for larval forms.

(*b*) Free-living forms in the water or on shore.

PLANARIANS and NEMERTINES (*see* Fig. 73) are numerous, being generally found under stones between tide-marks or dredged in shallow water. The NEMERTINES are often in tangled masses. Empty shells should be examined for them, and also sea-weeds. Some Nemertines make gelatinous tubes, or even burrows in the mud. Pelagic Nemertines, swimming freely at the surface, are very rare.

Free-living NEMATODES are not uncommon in the sea, chiefly in shallow water.

A single NEMATOMORPH, *Nectonema*, has sometimes been caught by the tow-net swimming at the surface.

POLYCHÆTA (*see* Figs. 66, 67 and 74, and pp. 187, 188) are very abundant. Unless dredging operations can be carried out, they are best obtained by shore-collecting at low tide. The burrowing kinds often betray their presence by leaving "casts" of sand (which has passed through the alimentary canal) on the surface of the ground, and may be obtained by digging in such spots.

GEPHYREA (*see* Fig. 68) will, as a rule, only be obtained by dredging, but a few may be found between tide-marks, burying themselves in mud, or forming tubes, or tubular excavations in soft rock. Some live as "commensals" with corals or sea-urchins, or in empty shells.

OLIGOCHÆTA are rare on the shore, but a few forms have been found among seaweed or under stones above high-water mark, and some small species are partly marine.

For LEECHES, *cf.* ii (*a*), p. 196.

For PHORONIDEA, *see* p. 189.

ENTEROPNEUSTA (*see* Fig. 75) may be looked for on sandy shores at extreme low-tide mark. They form large

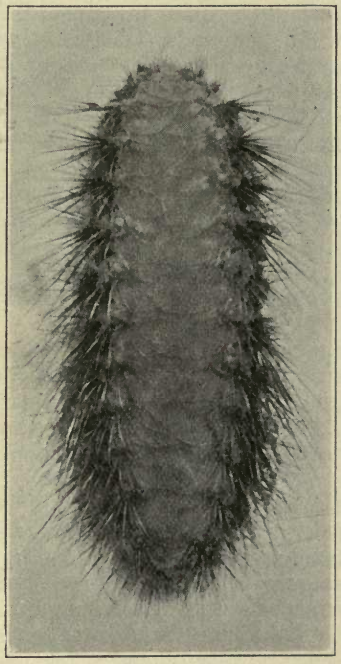


FIGURE 74.
Hermione hystrix, one of the spiny Polychætes, related to the "sea-mouse"; slightly enlarged. [CHÆTOPODA.]

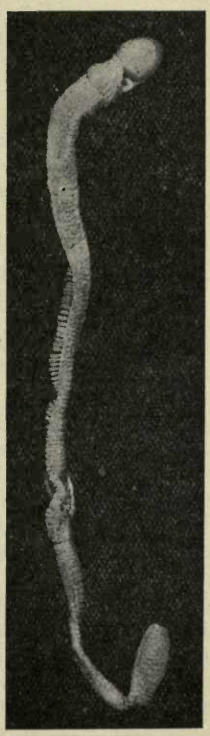


FIGURE 75.
Ptychodera minuta, enlarged about 1½ diameters. [ENTEROPNEUSTA.]

sand-casts, resembling those of Polychætes, and they may be found by digging in the neighbourhood of these casts. They must be handled with great care (*see* p. 191).

V.—List of Useful Chemical Reagents.

Acetic Acid, Glacial (*see* "Corrosive Sublimate"). Only a very small quantity of this will be required. Its use is to counteract the shrinkage of tissues, caused by solutions containing corrosive sublimate. A few drops added to the solutions are sufficient.

Alcohol. The best is "pure spirit," which can often be obtained more easily abroad than in England, where the heavy duty makes its price almost prohibitive. The strength of the spirit as purchased should be about 90 per cent., but for most purposes 70 per cent. is strong enough for use. This strength is obtained closely enough by adding 70 volumes of the 90 per cent. spirit to 20 volumes of water. Similarly, a solution of about 50 per cent. is obtained by diluting 50 volumes of 90 per cent. spirit with 40 volumes of water.*

Ordinary "methylated" spirit is unsatisfactory for use, and it has the disadvantage of becoming cloudy on dilution with water. What is known as "Industrial methylated spirit" is suitable, however, for preserving specimens. In England it can only be obtained by special permit from the Customs authorities, and only in considerable quantities.

Sudden changes in the strength of this reagent should be avoided. Thus if it be desired to transfer specimens from corrosive sublimate to alcohol, they should be placed, after washing with water, in a weak solution of alcohol before being transferred to stronger spirit.

Chloral Hydrate (Crystals), used for narcotizing certain kinds of worms (*e.g.* Nemertines) before killing them, so as to cause them

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* It will be seen by reference to No. 13 (p. 212) that the rule for diluting spirit which is indicated by these examples is correct for quantities and percentages mixed by weight, but not by volume.

to die expanded. A few of the crystals may be added to the sea-water, or the animals may be placed in a 1 per cent. solution of the substance made up in sea-water. Further remarks about narcotizing are made on page 205.

Corrosive Sublimate ($HgCl_2$). A saturated solution of this exceedingly poisonous substance in fresh water (or sea-water for marine animals) is a very useful killing and preserving fluid. Its action is extremely rapid, and is made even more so by heating. The solution is best made by putting more of the crystals in a vessel of water than will dissolve; but as solution takes place slowly the mixture should be made some hours before it is likely to be wanted. As the solution is used more water can be added at intervals. So long as some of the crystals remain undissolved the solution will remain "saturated." For delicate specimens which are not calcareous it is useful to add a few drops of glacial acetic acid to the solution. Steel instruments should not be brought into contact with solutions of corrosive sublimate.

Objects hardened with corrosive sublimate should be soaked for some hours in water or, better, in iodised alcohol (alcohol 70 per cent. 100 parts; tincture of iodine 2·5 parts) before being placed in alcohol for keeping. Otherwise the sublimate may crystallise out in the tissues, and spoil the specimen when subsequently mounted for the microscope.

N.B.—The saturated solution of sublimate looks exactly like plain water, and the bottle containing it should be labelled "Poison."

Formalin. The commercial formalin as bought is a solution of the gaseous compound *formaldehyde* in water. Its strength is about 40 per cent. For use it may be diluted with several times its bulk of water; hence it is very convenient for certain purposes, owing to its portability. It is also much cheaper than spirit. The strength most convenient for preserving animals is a 10 per cent. solution of formalin (or, which is the same thing, a 4 per cent. solution of formaldehyde). This is made by diluting one volume of commercial formalin with 9 volumes of water. After having been preserved in this solution specimens may be kept in a weaker one—say 5 per cent. (5 parts commercial formalin to 95 of water).

Note.—As formalin does not give good results with many kinds

of animals, some caution must be used in employing it. It is advisable not to preserve *all* the specimens of a kind in it, but to keep some in alcohol. Further, formalin contains a certain amount of acid, which is injurious to animals with calcareous structures, such as worms with calcareous tubes, or jaws in which the hardening matter is calcareous. Hence Polychætes should generally be preserved in alcohol rather than in formalin. For marine animals the formalin may be diluted with sea-water instead of with fresh water—an advantage which this reagent has over alcohol. N.B.—Formalin should not be used for preserving Nematodes, as it is liable to cause the specimens to burst.

Glycerine. This may be used, with special precautions, to preserve the natural colour of an animal. But as this reagent produces strong shrinkage in the tissues, it is essential to transfer the specimen into it gradually. This can be done by using successively stronger solutions of glycerine. The specimen may first be placed in a 10 per cent. solution of formalin containing a *small* quantity of glycerine. After a suitable interval (perhaps half an hour) the specimen, now hardened by the formalin, may be placed in a stronger solution of glycerine in water; and this process must be repeated each time with an increasing strength of glycerine. If the colour is not too fugitive, the specimen may be hardened in alcohol *for a short time*, transferred to a dilute solution of glycerine in alcohol, and then left in an open dish for the glycerine to concentrate itself by evaporation. In a hot, dry climate a formalin solution of glycerine might be left to concentrate itself in the same way.

Whatever method is adopted, the specimen should be brought into glycerine of full strength before the colour is lost.

Iodine, tincture of. A small quantity of this will be useful (*see* "Corrosive Sublimate").

Magnesium Sulphate (crystals). *See* p. 133.

Sodium Chloride (common salt). A weak solution of this substance should always be kept ready to hand for the preliminary washing of parasitic worms. 1 gramme of salt dissolved in 99 cubic centimetres of water will give the required strength (or about 1 ounce in 5 pints).

VI.—Apparatus.

A few dissecting instruments will be required by those who intend to look for parasites. They need not be many or costly, but the following are indispensable :—

Forceps.—Two or three pairs of various sizes, including one large and strong pair, and one with slender points.

Scissors.—A large strong pair for cutting open animals (sometimes better than a knife). Smaller dissecting scissors, one pair of which should be blunt-ended.

Scalpels.—Three or four of different sizes and shapes.

Needles.—A few of different sizes mounted in wooden handles.

Camel's hair brushes.—One or two.

Glass vessels.—Specimen tubes, with corks, of various sizes, will be required, and can be obtained cheaply from dealers in natural history requisites.

For larger specimens any kind of wide-mouthed bottles with sound corks or stoppers may be used, but perhaps the best are those with screwed-on metal lids and rubber rings.

A few test-tubes will be useful in cleaning specimens, as described below.

Tins, closed by soldering, may be used for specimens in spirit. They should under no circumstances be employed for specimens in formalin, which corrodes the metal.

Glass pipettes, fitted with rubber teats, are useful for picking up and transferring small specimens. "*Dipping tubes*," or straight pieces of glass tubing, with their cut edges rounded by placing for a few seconds in a flame, are useful for similar purposes, especially for capturing small creatures contained in deep vessels of water. (The method of using a dipping tube is as follows : close one end with a finger, and bring the other end down into the water until close to the specimen. Then remove the finger, when water will rush up the tube, carrying the specimen with it. Replace the finger over the upper end of the tube, and withdraw the tube from the vessel.)

Dishes.—Shallow glass or porcelain dishes may be used for containing the fluids in which specimens are to be killed or

washed, but an ordinary saucer, plate, or other such vessel will serve most purposes equally well. Enamelled iron vessels are particularly useful when travelling—*e.g.* for heating the alcohol with which Nematodes are to be preserved. For this purpose they need only be wide enough to allow the specimens to be straightened out, and should not be too shallow, in order to lessen the possibility of the spirit being set on fire.

VII.—Special Methods for the Treatment of Specimens.

Cleaning. Having collected the specimens, the first thing to do is to clean them from foreign matter, which may be difficult to remove after they have been killed.

All parasitic worms may be washed by shaking in the 1 per cent. salt solution. Nematodes and Trematodes can be shaken up vigorously in a test-tube without damage, but care must be taken with Tapeworms, which are very fragile. Water alone may be used for the washing if salt solution cannot be had, but specimens, especially Nematodes, must not be left long in it. In some cases, such as Chætopods, a soft camel's hair brush may be used to remove particles of sand, etc., which cling to their bodies, especially if they are very bristly.

Killing. After washing, the specimens must be killed with some reagent which leaves them in a suitable condition for subsequent examination—*i.e.* which "fixes" their tissues in a condition as nearly as possible approaching that of life.

The most generally useful reagent is *Corrosive Sublimate* (*see* list of reagents, p. 201). The effect is more instantaneous if the solution be heated, and the animals then plunged into it; but it may also be used cold. An hour or two in this solution will be long enough for the largest specimens; for smaller ones a few minutes will suffice. For necessary treatment *after* corrosive sublimate, see this heading in the list of reagents.

Formalin (10 per cent. solution) is also good for most worms, except for Nematodes, but it cannot be recommended for the majority of marine forms; specimens left in this reagent for 24 hours can then be transferred to the weaker solution, or at first to

weak, then to stronger alcohol. Large Chætopods may be killed with weak alcohol, keeping them stretched out straight and then preserving in stronger alcohol. For Nematomorpha either corrosive sublimate solution with acetic acid, or a weak formalin solution, is recommended. They may afterwards be stored in alcohol, with a little glycerine added.

For parasitic worms, *see* p. 206.

NARCOTIZING. As it is desirable to get the animals to die in an expanded condition, it is useful in some cases to anæsthetize them before killing. This is especially the case with Nemertines, and worms which live in tubes. Marine worms may be placed for 6 to 12 hours in a solution of chloral hydrate in sea-water (1 per cent.), or a few of the crystals may be added to the sea-water in which they lie. When fully extended and showing no sign of sensation, they may be preserved with formalin or alcohol. Eucaine or cocaine* may be used with advantage instead of chloral hydrate.

Another method is to place the worms in a shallow dish of sea-water, and gently pour about $\frac{1}{20}$ part of strong alcohol (not methylated spirit) on the surface. This will slowly mix with the water and anæsthetize the animals gradually. They can then be transferred to alcohol to harden, and preserved in it. Some of the free-living Polychæta must be thus treated or they will break into many little pieces when a killing reagent is added.

For the use of *Magnesium Sulphate*, *see* p. 133.

Note.—In tropical countries narcotizing is sometimes found difficult, owing to the fact that decomposition sets in before the

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* *Use of cocaine in the preservation of animals.*—By recent legislation the possession of cocaine by unauthorised persons has been made illegal, under heavy penalties, and no person, other than duly registered medical practitioners, registered dentists, registered veterinary surgeons or registered chemists carrying on a retail business in accordance with the Pharmacy Acts, is entitled to purchase or be in possession of the drug, unless he is the holder of a special permit, issued by the Home Secretary. Eucaine is not subject to this restriction, and this substance will probably be found to give results as good as those to be obtained by the use of cocaine, in many if not in most cases. It is accordingly recommended that where cocaine is mentioned as suitable for purposes of narcotization in this number of the "Instructions" preliminary experiments should be made with eucaine before applying to the Home Office for permission to purchase or use cocaine.

anæsthetic has had time to take effect. In such cases the alcohol method will be found to give better results than chloral hydrate.

Special Methods for Parasitic Worms.

Nematodes.

After washing thoroughly as above directed,* kill by plunging each separately into a quantity of *hot* 70 per cent. alcohol. A temperature of 50°–60° C. is high enough.

(N.B.—Care must be used, as the vapour given off is highly inflammable.) The advantage of this method is that the worms should die in a straight position, and without shrinkage.

After being killed in this way and allowed to cool, the worms are to be stored in fresh 70 per cent. alcohol (never in formalin).

Acanthocephala.

These worms must not be left long in salt-solution, but should be cleaned rapidly with a brush and subjected to gentle pressure between two slips of glass until the proboscis is protruded. They may then be killed by running in strong alcohol between the slips, an even pressure being maintained. After killing they may be stored in alcohol.

Trematodes.

After the first shaking up in salt solution the dirty liquid is poured off, and a small quantity of fresh salt solution introduced. The worms are shaken vigorously in this, and an equal quantity of saturated solution of corrosive sublimate added quickly, the shaking being then continued for several minutes. This should kill and fix the worms in an extended position. They may be left in the fluid for several days, or transferred at once to water, in which they should be washed for about twelve hours, unless iodised alcohol is used (*see* p. 201). After this they may be stored in 70 per cent. alcohol as usual.

[Formalin may be used, instead of corrosive sublimate, in a solution of 10 per cent. strength, followed by a weaker solution (about 3 per cent.) as a storing fluid.]

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* In the case of Nematodes with a mouth-capsule, a thorough shaking-up is necessary to remove parts of the tissues of the host, or other *débris*, from it.

Cestodes.

Wash gently in salt solution ;* then fix in a solution containing equal parts of saturated corrosive sublimate and 70 per cent. alcohol, to which a few drops of glacial acetic acid may be added with advantage—the whole heated to about 50° C. The Tapeworms should remain in the fixing fluid till it is cold; they are then washed in gently running water or in iodised alcohol for twelve hours, and stored in 70 per cent. alcohol.

VIII.—Packing of Specimens.

The bottles or tubes containing worms should be filled as full as possible with the preserving fluid (alcohol or formalin), and damage to the specimens by shaking may be prevented by a light packing of cotton-wool or tissue-paper. Care must be taken to insert the wool in such a way that the small specimens cannot get entangled in it. The liquid must not be allowed to dry up. When they are to be forwarded all the small bottles or tubes, containing the same preserving fluid, should be placed in a large, wide-mouthed bottle with a sound cork or a glass stopper, or a screwed-on lid with rubber ring. In this the tubes should be packed lightly with wool, horse-hair, or soft paper screwed up into loose balls, and the whole filled up with the fluid. It is a good plan, if the large bottle or jar is well stoppered and protected against breakage, to leave the tubes without corks, simply plugging their necks with a pellet of cotton-wool or a stopper of pith—*e.g.* elder-pith—and then stand them upside-down in the large jar. There is then much less risk of the fluid in the tubes getting dried up, so long as there is plenty in the big jar. Air-bubbles in the tubes should be avoided as far as possible.

N.B.—Tubes or small bottles packed in this way, immersed in fluid, must have their labels *inside*, and not gummed on the outside.

* When the Tape-worms are long and tend to become much tangled they should be washed in a shallow dish, and picked out one by one on a splinter of wood (not a metal instrument) and transferred to the fixing fluid.

Alcohol and Alcoholometers.

THE strength of a mixture of alcohol and water is ascertainable by means of a specially graduated form of hydrometer, known as an *alcoholometer*. Pure spirit is considerably lighter than water, its specific gravity at 60° Fahr. (= $15\frac{5}{9}$° Cent.) being ·7936, while that of water at the same temperature is 1·000. When alcohol is added to water the specific gravity of the mixture naturally depends on the proportions of its constituents. The stronger the spirit the lighter it will be, and more and more of the stem of the alcoholometer will be immersed in the fluid as the amount of alcohol in the mixture is increased.

While the alcoholometer is thus essentially an instrument for ascertaining the specific gravity of fluids, the graduation of its stem usually indicates the proportion of alcohol in the mixture; and this can be expressed in more than one way.

The instrument employed by Excise officers in this country indicates the strength of alcohol in relation to what is termed *Proof spirit*, a mixture composed of about equal parts by weight of alcohol and water. The strengths of alcohol which are weaker than Proof spirit are measured by a scale of 100 degrees, while those which are stronger than Proof spirit are similarly measured by a scale of about 75 degrees. Pure water is 100 per cent. *under Proof*, and pure spirit is 75·35 per cent. *over Proof*. One hundred gallons of spirit which is 5 per cent. over Proof will be reduced to Proof spirit by adding sufficient water to make the volume of the mixture up to 105 gallons; while spirit which is 5 per cent. under Proof contains 95 gallons of Proof spirit in every 100 gallons.

In another kind of alcoholometer the numbers marked on the

stem indicate the *percentage of alcohol* in the mixture. If a pint of pure alcohol weighed exactly as much as a pint of pure water, a mixture containing 50 per cent. by weight of alcohol would be identical with one containing 50 per cent. by volume. But alcohol has the specific gravity of ·7936, or roughly ·8; and this means that it is only about $\frac{4}{5}$ as heavy as water. In a mixture of equal *volumes* the alcohol will accordingly weigh less than the water while to form a mixture of equal *weights* the alcohol must be of greater volume than the water.

There are thus three distinct kinds of alcoholometer in ordinary use, giving readings respectively :—

(1) over and under Proof ;
(2) as percentages of alcohol by volume ;
(3) as percentages of alcohol by weight.

A reading (say 75) on (2) means that the spirit tested has the composition which would be obtained by mixing 75 *volumes* of pure alcohol (or "absolute alcohol") with sufficient water to make 100 volumes of the mixture. The same reading on (3) would indicate the mixture that would be formed by adding 75 *parts by weight* of the pure alcohol to 25 parts by weight of pure water.

The relations between the scales above indicated are complicated, and the difficulty of comparing them is increased by another fact. If a pint of pure alcohol is added to a pint of water, the volume of the resulting mixture is not two pints, but is some smaller quantity, owing to the fact that a substantial amount of contraction occurs when the two fluids are mixed. By carefully measuring the amount of this contraction for each strength of alcohol it has been possible to construct tables showing the relation between the readings given by the two forms of alcoholometer (2) and (3). The importance of knowing which kind is actually being used is indicated by the fact that Proof spirit is the same as about 57 per cent. in (2) and about 49 per cent. in (3).

In using alcoholometers indicating the percentage of pure alcohol by volume, the readings are only correct at the temperature (usually 60° Fahr.) at which the instrument has been adjusted. To find the true strength at any other temperature, reference must

be made to a table of corrections. Such a table is usually supplied with each instrument, and, it must be remembered, is only applicable to that instrument or to another similar instrument made with precisely the same quality of glass. The necessity for correcting for temperature is due to the fact that mixtures of alcohol and water of different strengths expand and become lighter, and contract and become heavier, at different rates with change of temperature. If the temperature of the mixture exceeds that at which the instrument was adjusted, the fluid will be lighter than it would be at that temperature, and the reading of the alcoholometer will accordingly indicate a greater strength of alcohol than is really present. If, on the other hand, the temperature is lower, the reading will indicate too weak a grade of alcohol. It thus follows that if the mixture which is being tested has a temperature differing from 60° Fahr. the reading must be corrected according to a scale which has been worked out for various temperatures.

A collector engaged in preparing Natural History specimens need not attempt to estimate the strength of the alcohol he is using with minute accuracy. But it is important for him to realise that the use of spirit which is too weak may entirely spoil the results of his labours, and that in practice the spirit in which the specimens are contained at the end of the process of preparation should always be well over Proof, or, in other words, should consist of considerably more than 50 per cent. by weight of alcohol. Weak grades of spirit may, however, be used with advantage in some of the early stages of preparation, one object of which is to remove water from the tissues and to replace it by alcohol. The strongest spirit, on the other hand, is as a rule not suitable for use, as it may produce shrinkage and often renders the specimens so hard and rigid that they cannot be examined without difficulty.

It thus becomes necessary to have, at any rate an approximate idea of the nature and strength of the alcohol used; and it is convenient to have some simple rule for the preparation of spirit of a given grade from stronger alcohol.

Pure spirit, which is specially to be recommended for the preservation of animals, consists of a mixture of ethyl alcohol

and water; and is often sold at a grade of 40 over Proof, or about 80 per cent. of alcohol by volume. It is unfortunately very expensive, owing to the heavy tax which has to be paid.

Methylated spirit is a mixture of ordinary ethyl alcohol with wood naphtha (crude methyl alcohol). The wood naphtha is mixed with the alcohol under Excise supervision, and has to be of an approved type; the average composition, in 100 parts by volume, being methyl alcohol 77 parts, acetone 10 parts, and methyl acetate $1\frac{1}{2}$ parts. The remainder required to make up to 100 parts is mainly water.

There are two kinds of methylated spirit:—

(a) *Mineralized methylated spirit*, which is a mixture of 90 parts of alcohol* and 10 parts of wood naphtha, together with $\frac{3}{8}$ of 1 per cent. of mineral oil and traces of methyl violet colouring matter. This is the methylated spirit ordinarily sold. It is almost useless for preserving animals, as it cannot be diluted without forming a milky emulsion.

(b) *Industrial methylated spirit*, which is a mixture of 95 parts of alcohol* with 5 parts of wood naphtha. It has a strength of 62 to 66 over Proof (92 to 95 per cent. of alcohol by volume). This is the methylated spirit used for manufacturing and scientific purposes.

Industrial methylated spirit can only be obtained from methylators or makers of methylated spirit. Methylators are authorized to supply it only to persons who have obtained the permission of the Commissioners of Customs and Excise to use it.

No difficulty will usually be found in obtaining the necessary permission to use this spirit in preserving animal or vegetable specimens. Application should be made to the nearest Customs and Excise Office for a form of request for permission, to be filled up and sent to the Commissioners. The officials will generally give any assistance or information required. On obtaining permission, order-forms will be supplied which can be sent to any convenient methylator. The minimum quantity that can be

* The alcohol here referred to is the ethyl alcohol of high strength used in making the methylated spirit. It is from 62 to 68 over Proof, or, in other words, it contains from 92 to 96 per cent. by volume of ethyl alcohol.

supplied is 5 gallons, but there is no restriction on the time within which it may be used.

The *reduction of strength* of alcohol of known percentage composition by weight to a weaker grade may be effected by means of the following simple rule :—

Let A be the percentage by weight of the alcohol it is desired to dilute, and let B be the percentage of alcohol it is desired to have in the new mixture. The result required will be arrived at by adding $A - B$ parts by weight of water to B parts by weight of the alcohol of percentage A.*

Examples.—To make 50 per cent. alcohol from 95 per cent. alcohol, add 45 [= 95 *minus* 50] grammes of water to 50 grammes of 95 per cent. alcohol.

To make 40 per cent. alcohol from 70 per cent. alcohol, add 30 grammes of water to 40 grammes of 70 per cent. alcohol.

Larger or smaller quantities can be made by using different units of measurement or by multiplying or dividing the quantities by a suitable number. Thus, in the first example, ounces might be used instead of grammes, or the quantities might be divided or multiplied by 5. The desired result would thus be arrived at by adding 9 ounces of water to 10 ounces of 95 per cent. alcohol ; or by adding 225 grammes of water to 250 grammes of 95 per cent. alcohol.

The rule here given is correct in dealing with quantities and percentages measured by weight, but it is not correct for quantities and percentages measured by volume. The correct number of volumes (x) of water required to dilute 100 volumes of alcohol, of percentage v by volume, and specific gravity D, to form a mixture of percentage v^1 by volume and specific gravity D^1, is

$$x = 100\left(D^1\frac{v}{v^1} - D\right).$$

* The equation

$$x = \frac{100\,(A - B)}{B}$$

gives the amount of water (x) required to dilute 100 parts by weight of alcohol of the percentage A to such an extent as to transform it into alcohol of the percentage B.

The following table (A) gives the relation between the different kinds of alcoholometer.

TABLE A.—RELATION BETWEEN THE SPECIFIC GRAVITY AT 60° F. ($15\frac{5}{9}$° C.) AND BRITISH PROOF STRENGTHS AS SHOWN BY SIKES' HYDROMETER, AND THE EQUIVALENT READINGS AT THE SAME TEMPERATURE ON ALCOHOLOMETERS GIVING PERCENTAGES OF ALCOHOL BY VOLUME OR BY WEIGHT.

Specific gravity.	Degrees under and over Proof on Sikes' Hydrometer.	Percentage of Alcohol.	
		By weight.	By volume.
	Temperature 60° F. ($15\frac{5}{9}$° C.) in air.		
1·0000	100·0 under Proof	0	0
·9928	91·23 ,, ,,	4·02	5·03
·9866	82·56 ,, ,,	8·04	9·99
·9811	73·85 ,, ,,	12·12	14·98
·9760	65·13 ,, ,,	16·25	19·98
·9709	56·56 ,, ,,	20·42	24·98
9654	47·56 ,, ,,	24·67	30·00
·9591	38·80 ,, ,,	28·97	35·00
·9518	30·02 ,, ,,	33·36	40·00
·9435	21·23 ,, ,,	37·86	45·00
·9343	12·47 ,, ,,	42·48	49·99
·9242	3·68 ,, ,,	47·24	55·00
·91976	*PROOF*	*49·28*	*57·10*
9134	5·10 over Proof	52·15	60·01
·9020	13·84 ,, ,,	57·18	64·98
8899	22·63 ,, ,,	62·42	69·99
·8772	31·39 ,, ,,	67·85	74·98
·8637	40·21 ,, ,,	73·51	80·00
·8494	48·98 ,, ,,	79·41	84·98
·8337	57·79 ,, ,,	85·68	90·01
·8159	66·56 ,, ,,	92·40	95·00
·7936	75·35 ,, ,,	100·00	100·00

The figures given above refer to mixtures of ethyl alcohol and

water, or, in other words, to "pure spirit." When an alcoholometer is used with either kind of methylated spirit, its readings are obviously affected by the presence of the methyl alcohol and other substances which have been added by the methylator. But for the practical purposes of the collector this consideration may be disregarded.

The chief constituent, other than ethyl alcohol, of "industrial methylated spirit" is methyl alcohol. The readings of the alcoholometer shown on testing this kind of methylated spirit, or its dilutions with water, give approximately the percentage of the ethyl alcohol added to that of the methyl alcohol in the mixture, the strength of which may be regarded for practical purposes as if it were a mixture of ethyl alcohol and water only.

A table in which the number of volumes of water required to dilute alcohol of certain specified strengths so as to produce weaker grades of alcohol is given on p. 353 of "Science of the Sea,"* a work where much valuable information about the use of preservatives may be obtained.

If it be desired to calculate the percentage of alcohol by weight from the readings of a volume alcoholometer, this can be done by means of the following equation :—

$$x = v\frac{d}{D}$$

where x is the percentage by weight required, v the percentage number of volumes of alcohol indicated by the alcoholometer, d the specific gravity of pure alcohol, and D the specific gravity of the spirit of the composition v.

Similarly, the percentage of alcohol by volume can be calculated from the readings of an alcoholometer giving percentages by weight by means of the equation

$$x = p\frac{D}{d}$$

* Edited by Dr. G. H. Fowler; London, John Murray, 1912, 6*s*.

where x is the percentage by volume required, p the percentage number of parts by weight of alcohol indicated by the alcoholometer, d the specific gravity of pure alcohol, and D the specific gravity of the spirit of the composition p.

The approximate corrections for temperature, for spirit measured by the alcoholometer ordinarily supplied to the collectors of the British Museum, are given by Tables B, C, and D.

TABLE B.—TEMPERATURE-CORRECTIONS FOR USE WITH SPIRIT OF 40 OVER PROOF OR GREATER STRENGTH.

Temp. Fahr.	32½°	36½°	41½°	45°	49°	53°	56½°	60°	64°	67½°	71°	74½°	78°	81°	84½°
	+7	+6	+5	+4	+3	+2	+1	0	−1	−2	−3	−4	−5	−6	−7

TABLE C.—TEMPERATURE-CORRECTIONS FOR USE WITH SPIRIT FROM 40 OVER PROOF TO PROOF.

Temp. Fahr.	34°	38°	41°	44½°	47½°	51°	54°	57°	60°	63°	66°	69°	72°	75°	78°	81°	84°
	+8	+7	+6	+5	+4	+3	+2	+1	0	−1	−2	−3	−4	−5	−6	−7	−8

TABLE D.—TEMPERATURE-CORRECTIONS FOR USE WITH SPIRIT FROM PROOF TO 40 UNDER PROOF.

Temp. Fahr.	32°	35°	38°	41°	44°	46½°	49°	52°	55°	57½°	60°	62½°	65°	67½°	70°	72½°	74½°	77°	79°	81½°	83½°
	+10	+9	+8	+7	+6	+5	+4	+3	+2	+1	0	−1	−2	−3	−4	−5	−6	−7	−8	−9	−10

In using the above tables, find the observed temperature of the mixture as nearly as possible in the table. The figure given in the second line indicates the number to be added to or subtracted from the reading of the alcoholometer. If the temperature is

below 60° Fahr. the number indicated must be added to the reading (Tables B and C); if above that temperature it must be subtracted.*

Examples.—If the alcoholometer indicates 5 over Proof at 84° Fahr., Table C shows that 8 must be subtracted from that reading, the real strength of the spirit being 3 under Proof.

If the alcoholometer indicates 20 under Proof at 79° Fahr., Table D shows that the reading is 8 degrees too high, the real strength of the spirit being 28 under Proof.

The temperature-correction required for an alcoholometer indicating percentages of alcohol† may be taken as ·4 per cent. for each degree of temperature above or below 15° Cent., to be added to the reading of the alcoholometer for temperatures below 15° Cent. and subtracted for temperatures above that amount. With the Fahrenheit thermometer ·22 per cent. should be added to the reading of the alcoholometer for each degree of temperature below 59° Fahr., and subtracted from the reading for each degree above 59° Fahr.

---

* A mixture which is 10 over Proof contains more alcohol than one which is 9 over Proof; but a mixture which is 10 under Proof contains less alcohol than one which is 9 under Proof. The second example shows that the rule given above must be inverted in using Table D.

† These corrections refer properly to alcoholometers indicating percentage composition by volume, but they can be used, with sufficient accuracy for practical purposes, for alcoholometers indicating percentages by weight.

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DUKE STREET, STAMFORD STREET, S.E. 1, AND GREAT WINDMILL STREET, W. 1.

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